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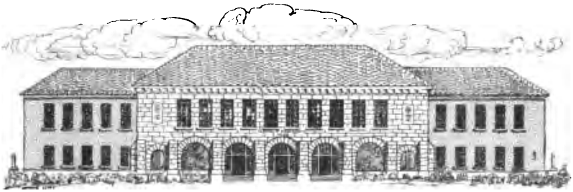

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OBJECT LESSONS

IN

ELEMENTARY SCIENCE

OBJECT LESSONS
IN
ELEMENTARY SCIENCE

FOLLOWING THE SCHEME ISSUED BY THE
LONDON SCHOOL BOARD

DEPARTMENT OF EDUCATION
LELAND STANFORD JUNIOR UNIVERSITY

BY

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VOL. I

MACMILLAN AND CO., LTD.
BEDFORD STREET, STRAND, LONDON
NEW YORK: THE MACMILLAN CO.
1896

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First Edition July 1894
Reprinted with corrections October 1894
June and November 1895, 1896

PREFACE

SOME years ago the London School Board issued a Scheme of Object Teaching in Elementary Science. This Scheme was at once adopted by the compiler of these Lessons for use in his own school. He started by writing complete Notes of the Lessons, based on the Scheme, for each section of the school; and has exercised much care and thought in getting together a museum of suitable objects for illustrating the teaching.

The result has been a marked success—the teachers as well as the children deriving pleasure and benefit, and looking forward to the lessons as a welcome break in the monotony of the school routine.

H.M. Inspector has always shown his commendation of the work; and in July last he brought the Right Hon. A. H. D. Acland, the Vice-President of the Council, on a visit to the school for the purpose of witnessing the teaching in this subject.

The Vice-President spent about an hour and a half with the various classes, showed great interest in the work, examined the books of written lessons, and himself suggested the advisability of publishing them. Hence they now appear in book form.

A special point in the arrangement of the Lessons is that they are all written in full, no single step being left unexplained. The pupil-teachers can therefore be allowed to take their share of the work, to their own benefit and improvement, without loss to the children.

The instructions to the teachers are printed in italics, the salient points of the lesson are conspicuously shown in the change of type, and lists of suitable objects for illustrating each lesson are placed at the end of the book.

As the books are intended for the teacher and not for the class, there is no need for copious illustration. The plates at the end are intended for reproduction as black-board sketches, and generally for the guidance of the teacher. The teacher will reproduce on the black-board as much as he can of each sketch, according to his individual skill with the chalk.

The universal complaint from Inspectors in all parts of the country has been that the so-called "Object Lessons" too often fail in their purpose, because nothing is so conspicuous as the absence of the objects themselves. The main purpose throughout this course has been never to use a picture where the real object can (with a little trouble) be obtained; and the Author has found, and still finds, that the teachers as well as the children take a lively interest in adding to the stock of articles in the school museum.

The various stages are written up to the possibilities of a school of good repute, well appointed and staffed. In schools not so fortunately placed, a rearrangement of the

Standards might be made—Standards I. and II. taking the course prescribed here for Standard I., and so on.

In smaller schools, and girls' schools, the lessons dealing with Animal and Plant Life alone would make an interesting and useful course; or the lessons on Common Objects (Standards I.-III.) might be followed in the higher Standards by the course in Mechanics, Botany, Zoology, or Chemistry, at the teacher's pleasure.

The complete course covers almost the entire ground of alternative subjects prescribed by the Code of 1894.

The Author begs to acknowledge his indebtedness to Mr. Rick's admirable book, *Object Lessons and How to Teach Them;* also to *The Chemistry of Common Life; Animal Products; Strength of Materials and Structures; Dictionary of Manufactures;* and for trade statistics to the researches of friends.

SCHEMES OF LESSONS

STANDARD I

I. Lessons from Common Objects

1. **Plastic substances.**

Clay.—Its chief physical properties; changes produced by baking. Its uses for modelling and for making bricks, tiles, drain-pipes, pottery, etc.

Putty.—Made of crushed chalk and linseed-oil. Why linseed-oil. Its uses to be illustrated.

Gutta percha.—Comparison of properties when cold and when warmed in hot water. Articles made of gutta percha.

These lessons to be illustrated with prepared clay, putty, and gutta percha, which are to be placed in the hands of the children for test and experiment.

2. **Soluble substances.**—Meaning of soluble.

Sugar.—Its chief physical properties.

Rock-salt.—Its chief physical properties.

These substances to be placed in the hands of the children for examination and comparison.

Show, by means of the evaporating dish, how sugar can be recovered from the water which holds it in solution; and how table-salt is prepared from sea-water, and from brine springs.

3. **Some substances which burn.**

Coal.—Its physical properties and uses. Heated in a closed vessel gives off gas, which will burn, but which we cannot see. Illustrate with coal-dust in a clay pipe. Compare with other bodies which will burn, such as sulphur, wood, cork, and india-rubber, and illustrate in each case. Show also that animal substances, unlike vegetable, burn with difficulty. Illustrate with wool, sponge, leather, feathers, and whale-bone. Compare with fibrous asbestos, which gets white hot in a flame, but is not consumed.

4. Elastic substances.

India-rubber, cork, sponge.—Their chief physical properties and uses.

Illustrate the different kinds of elasticity by a comparison of these substances. How cold affects the elasticity of india-rubber. Manufacture of "elastic." Uses to which these substances are put dependent on their special properties.

II. LESSONS FROM PLANTS

1. **Parts of a plant.**—Roots, stems, branches, buds, leaves, flowers, fruit, seeds. Uses of these various organs treated in the simplest possible way. **Roots,** to take up food in solution from the soil; **stems and branches,** to carry the earth-food to the leaves and to support the leaves in the air and sunlight; **leaves,** to take in air, and to prepare the plant-food necessary to the growth of the plant; **flowers,** to produce fruit and seeds.

2. **Comparison of leaves.**—The general shape, the margin, the colour, the veins, etc., to be compared from actual specimens in the hands of the children.

III. LESSONS FROM ANIMALS

1. **The cat.**—Covering of hair and fur. The paws and claws, structure and uses. The eyes for seeing with a minimum amount of light. The rough dry tongue, and its special use. The sharp, pointed teeth, and their special use. The motion of the lower jaw, and why. Food, and how captured. Disposition. Some of the cat's larger relations—lion and tiger.

2. **The dog.**—Covering of hair. The paws and claws, and their uses. The large eyes and smooth wet tongue. The sharp, pointed teeth, and special use. Motion of the lower jaw. Why Food and how captured. Sense of smell very acute. Disposition. Compare in all respects with the cat.

3. **The sheep.**—Covering of wool; uses of wool. Food and how chewed; motion of the lower jaw. Teeth—flat-topped grinders, absence of incisors and presence of pad in front of upper jaw. Structure of feet; number of toes, and how they are covered. Mutton and lamb.

4. **The pig.**—Hairs and bristles; compare with fur and wool. Shape of head; the snout and its use. The cloven foot, number of toes. Tusks of wild boar. (Bacon and ham.) Compare in all respects with the cat, dog, and sheep.

STANDARD II

I. Lessons from Common Objects

1. **Porous substances.**—Meaning of porous.

Sponge, charcoal, blotting-paper, flannel—their physical properties and uses.

Sponge—how specially adapted for cleansing purposes.

Blotting-paper—how it takes up surplus ink; compare with writing-paper. Show how a roll of blotting-paper takes up a liquid, and compare with wick of candle. Illustrate by burning turpentine which has ascended through a piece of cane.

Filters.—Make sponge, charcoal, and blotting-paper filters. Illustrate their use. Filter a mixture of chalk and water, or flour and water, or ink through blotting-paper. The earth a filter. Clear water from springs.

2. **Soluble substances.**—Soda, alum, camphor (in spirits of wine). Physical properties and uses of these substances. Why we cannot see bodies in solution. Why raw starch makes water milky-looking. Use of soda for cleansing purposes. Soap made from fats and soda.

Further illustrate soluble (1) by making a saturated solution of alum in boiling water; stand in the solution some wire trinket, the wire being covered with worsted, and set aside to cool; (2) by adding to solution of salt a few drops of nitrate of silver solution, then a little ammonia solution ; (3) by adding a drop of water to spirit solution of camphor.

3. **Adhesive substances.**—Meaning of adhesive. Gum, glue, sealing-wax, mortar, cement, plaster of Paris. Special uses of these bodies. Illustrate by experiment in each case. Show how sealing-wax and plaster of Paris may be used for making casts. [In mixing plaster of Paris add the powder to the water gradually, and not the water to the powder.]

4. **Metals.**—Iron, copper, lead, tin, zinc, gold, silver—when clean and polished all are alike in being lustrous. Iron rusts away in time; copper, lead, tin, and zinc rust a little on the surface only; gold and silver do not rust.

These metals are hard and heavy, and can be melted ; but they vary in hardness and weight and the ease with which they can be melted.

After experimental illustration, these metals to be arranged as far as possible in order (1) of hardness, (2) of weight, (3) of fusibility.

Some metals can be hammered into sheets or drawn out into wires. Show specimens of sheets of iron, lead, copper, and zinc, also tin, zinc, and copper foil, and gold-leaf. Also wires of all kinds.

Compare as to malleability and ductility.

II. Lessons from Plants

1. **Starch.**—Illustrate its preparation from wheat-flour or potato. Made chiefly from rice and Indian corn. Starch-foods—corn-flour, sago, tapioca, and arrowroot. Illustrate the action of hot water on a mixture of starch in a little cold water; use in laundry, also for stiffening calico and for making British gum for postage-stamps and envelopes.

2. **Sugar.**—Its preparation from the cane, or from beetroot. Its special properties and uses. Sugar in fruits. Compare with starch as to properties.

3. **Wheat.**—Description of the growth of the plant. The stalk, the leaves, the ear of corn. Wheaten flour, why the best for making bread.

4. **Rice.**—Its cultivation to be described. Its use for food,

and for making starch. Rice-flour, why not used for bread-making. Compare with wheat, and refer to other cereals, such as maize, barley, and oats.

III. Lessons from Animals

1. **The cow.**—Covering of hair. Food and how chewed. Compare with the sheep. Structure of feet. Beef. Milk, its chief properties and uses. Preparation of butter and cheese.

2. **The horse.**—Special points in structure. The skin, mane, tail, hoofs, gap between front and back teeth. Special uses of tail and hoof. Shoeing. Compare with the donkey.

3. **The rabbit.**—Covering of fur. Long ears. Why. Gnawing animals. Why so called. Structure and growth of front teeth. Compare with carpenter's chisel. Whiskers, their special use. Thick blunt claws, their use. Compare with the hare.

4. **The monkey.**—Why called four-handed. Adapted to live in the trees. Structure adapted to habit. In some, the tail a fifth hand.

5. **The mole.**—Structure fitted to underground habit. Its fur—why it does not ruffle. The snout. The shovel-like fore-paws. The nails. How adapted for tunnelling. The minute eyes deeply set. Why. Habits of the mole. Its food. Its disposition.

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STANDARD I

STANDARD I

Lesson I

WATER

It is very important that boys and girls, and even little boys and girls, should learn to go about with their eyes wide awake. There are many things to be learned from the very commonest things around us, if we only take the trouble to use our eyes.

We are going to have a chat about some of these common things. You must try and help me to find out all we can about them, and that will show how (by always keeping your eyes open) you can find out other things for yourselves.

I. Water flows

One of the commonest things we see around us is water.

Make the children tell how and where we meet with water.

Now suppose I sent a boy into the next room for a book, a pen, or a piece of chalk, he would at once go and get it without any trouble. But if I asked him to bring me some water, he would first have to find something to hold the water.

Why is this? He cannot pick the water up in his hands as he can the book, the pen, and the chalk; it would run through his fingers.

Here is a jug of water. What would happen if I were to break a hole in the jug? The water would all run out and be spilt on the floor.

Now here I have some sawdust. See, I will fill this saucer with the sawdust, and this one with water from the jug. I can go on piling up the sawdust in a great heap, above the edge of the one saucer; but what about the water in the other? As soon as the saucer is full, the water runs away over the edge and spreads itself over the table.

Make a pile of sawdust on the table itself, and then show that the same cannot be done with the water.

Water will not stand up in a heap. It falls away and flows over the table, and if we allowed it to flow, it would run off the table on to the ground.

Suppose one of you were to overturn an ink-well on the desk. The ink would act just as the water does. You could not pick it up with your fingers. It would spread and flow over the desk. So too would milk, or oil, or tea, or vinegar.

Now pour some quicksilver gently on the table or on a slate and let the class see that this acts in the same way. It flows about.

Water, oil, vinegar, milk, quicksilver are all alike. They cannot stand in a heap. They flow or spread about on the table.

II. WATER FLOWS DOWN

Call attention to the rain. It falls from the clouds overhead, **downwards**; *it runs off the roofs of our houses,* **downwards**; *it flows* **down** *the pipes,* **down** *the gutters,* **down** *the drains;* **always down, never up.**

All the other substances, oil, milk, vinegar, quicksilver, do exactly the same—**they flow down.**

They only flow because they are always trying to get lower and lower down.

III. WATER BREAKS UP INTO DROPS

Dip a brush into a basin of water and sprinkle it on the floor.

The water falls in round drops.

Call attention to the drops as they fall, and show them as they run about on the dusty floor.

Now, instead of shaking the brush over the floor, shake it over another basin.

The drops fall from the brush as before, but they fall into the basin this time.

What becomes of the drops? Can you see them in the basin? We cannot see them as drops, because they have all run together and formed the little pool of water that lies at the bottom of the basin. I could take all the water from one basin and put it into the other in this way if I wished.

Compare the rain falling in drops and the drops running together and flowing away in a stream of water.

Pour carefully two or three drops from the bottles of oil, vinegar, etc. These substances separate into drops too.

Now let fall rather roughly a little quicksilver on the table, and show how it too breaks up into a vast number of very little round balls or drops. Some of these may be swept together again to form bigger drops.

All these substances, oil, milk, vinegar, and quicksilver, as well as water, break up into drops, and the drops are able to run together and unite again.

IV. WATER TAKES THE FORM OF THE VESSEL WHICH HOLDS IT

Call attention to the saucer of water standing on the table.

The water fills the saucer quite up to the brim.

What is the shape of the saucer? Round or circular.

Then what must be the shape of the water? Round too.

Now carefully pour the water out of the saucer into a square tin box, a tumbler, a jug, a bottle, or any other vessel ready to hand, and lead the class to see that in each case the water fills up every part of the vessel, and therefore takes the shape of it.

Show too that in each case the water always keeps a level surface. It cannot stand in a heap, it cannot slant.

The milk, oil, and other substances would do exactly the same as the water. They would take the shape of any vessel in which they were placed, and they always keep a level surface.

Now let us see what we have learned.

1. **Water, oil, wine, milk, quicksilver, all flow or spread about.**
2. **They all readily break up or separate into drops.**
3. **They have no shape of their own, but always take the shape of the vessel in which they are held.**
4. **They always keep a level surface.**

Now I want you to remember the name for all bodies of this kind. We call them **Liquids.**

1. Liquids are bodies which flow about, separate into drops, take the shape of the vessel which holds them, and always keep a level surface.
2. Water, oil, wine, milk, vinegar, and quicksilver are **liquids.**

Lesson II

LIQUIDS AND SOLIDS

As an introduction to the new work make the class recapitulate carefully, by means of simple questions, all that was taught last lesson about the nature of liquids. This should not take more than a few minutes, and it will make sure of the ground for what is to follow.

I. A Solid

Our last lesson dealt with substances which flow about.

Now see, I place this stone, this block of wood, and this piece of iron on the table. If I poured water on the tabl it would flow away, because it is a liquid.

Will the stone, the wood, and the iron flow away ? No. Then they are not liquids.

Water, being a liquid, breaks up very readily into little drops, and these drops can afterwards run together to form a body of water again.

Could I easily separate the stone, the wood, or the iron into small drops or particles, and could these particles run together again ? No ; they are not liquids.

Liquids have no shape of their own, but take the shape of the vessels which hold them.

Have this stone, this block of wood, and this piece of iron any shape of their own ? Yes, they have, and we cannot alter the shape of either of them.

Let one of the boys take the block of wood into his hand, and another the piece of iron, and try to squeeze them into any other shape.

He cannot alter the shape of either the wood or the iron with all his pressing.

Let another boy try with the stone.

He too fails to press it into any other shape. He can by striking the stone a smart blow with a hammer alter the shape, but in altering the shape he will have broken the stone.

Now put the stone, or the wood, or the iron into a basin, a tumbler, or some such vessel, and let the class see for themselves that these substances do not take the shape of the vessel in which they are placed.

All bodies which have a shape of their own which cannot be altered without pressure, we call Solids.

Make the class name all the solid things they can see around, and tell why they are solids.

II. SOLIDS INTO LIQUIDS ; LIQUIDS INTO SOLIDS

Experiment.—Here is a piece of wax. Is this a liquid or a solid ? It is a solid.

Let the class say why.

Now I am going to show you that we can change some solids into liquids, and liquids into solids.

Put the wax into a large iron spoon and hold it over the gas or the spirit-lamp.

The heat from the flame changes the solid wax into a liquid.

Make the class tell why we call it a liquid now.

When we put the wax in the spoon it stood in a lump in the middle, but did not touch the sides. It now fills the spoon; it has taken its shape; it flows about, and if I hold it still it will keep a level surface.

Now pour some of the liquid wax from the spoon into a large pill-box, and let it stand to cool.

As soon as it has cooled, show that the liquid has now again become a solid substance and fills the pill-box. Note too that the upper surface of the wax is level.

Can any one tell me of another substance that can be changed from the liquid into the solid state and back again?

Lead the class to think of water. In its usual, natural state it is a liquid, but when it is very cold, the liquid water is changed into solid ice. This is again changed into water as the weather becomes warmer.

We can pick up a piece of the solid water (or ice) in our hands, and throw it about without spilling any of it, without breaking it or altering its shape.

Let us now return to our pill-box. We can learn something more from that, I think.

See, I am going to cut open the box with my knife. I want to do it carefully so as not to touch what is inside.

Now it is cut open and I will take it off.

What have I got inside? A round piece of solid wax, exactly the same shape as the pill-box was when the melted wax was poured into it.

This proves to you that liquids do really take the exact shape of the vessels which hold them.

Lead the children to tell of other substances that can be changed from the solid into the liquid form and back again.

The solid fat in the piece of meat roasting in front of the fire becomes changed by the heat of the fire into a liquid, and falls or flows away in drops into the dripping-pan below.

The cook takes it up in this liquid form in the spoon, and pours it over the joint to baste it. When she takes it up in the spoon it fills the spoon and takes its shape. **It is a liquid.**

When the meat is cooked the liquid fat is poured out of the dish into a basin, and **we see it after a time in the solid form again.** If we turn it out of the basin when it is cold, **we see that it has taken the shape of the basin.**

Let this be deduced step by step from the class.

Make the children tell next of substances which cannot be changed from one form to the other, e.g. *wood, brick, slate, stone, coal, coke, etc.*

Lesson III

HARD AND SOFT BODIES

One of the first ideas to strike a child as he comes into contact with various objects must be the difference in touch between one and another. It will be the aim of this lesson to enlarge the idea so as to enable the child to express clearly—

1. What he understands by "hard" and "soft."
2. That this hardness and softness are relative terms.
3. How he can test bodies for himself and so on.

I. A simple Test

Distribute some pieces of flint, iron, and wood, and a few handfuls of feathers, or cotton-wool, or one or two sponges round the class.

Let one of the children take the flint, iron, or wood in one hand, and the sponge, feathers, or wool in the other. Tell him *to close both hands as tight as possible, and then make him explain what he has observed.*

It is easy enough to squeeze the sponge, the feathers, and the wool, as the hand closes upon them; but with all his trying he cannot squeeze the iron, the flint, or the wood.

The feathers, the wool, and the sponge yield to the pressure, and we call them *soft bodies.*

The flint, the iron, and the wood will not yield, and these we call *hard bodies.*

Let the class next give examples of hard and soft bodies, the teacher meanwhile arranging them in two columns on the blackboard.

II. ANOTHER TEST

1. *Let one of the pupils now come to the front, and try to scratch with his finger-nail some of the substances lying on the table, commencing with the apple, the turnip, and the potato, and afterwards taking the cork, chalk, wood, lead, iron, flint, steel, and glass.*

Make him tell what he has observed.

(*a*) The apple, turnip, and potato, he can scratch very easily.
(*b*) The cork and the chalk he can also scratch, but not so easily as the others.
(*c*) The wood and the lead he can just scratch with his nail.
(*d*) The iron, steel, flint, and glass, he cannot scratch at all.

2. *Let him next proceed in the same way with a knife, commencing this time with the cork, and make him again tell what he observes.*

(*a*) The cork and the chalk he cuts easily.
(*b*) The wood and the lead he cuts too, but with more difficulty than the cork.
(*c*) The iron, steel, flint, and glass he cannot cut with the knife.
(*d*) The flint, steel, and glass he cannot even scratch.

3. *Now let him take the different substances, and rub them one against another, and call upon him to explain, as before. In this way it will be made clear that the harder body will scratch, mark, or cut the softer one.*

Now what have the class learned by these tests?

They have learned—

1. That although we call certain bodies hard and others soft, there are many degrees of hardness.
2. That these terms of hardness and softness can only be used when one body is set by the side of (compared with) another body.
3. Some bodies which we call hard are really soft when compared with others.

Make them tell that **lead is hard when compared with wood or chalk, but soft when compared with iron; iron hard when compared with lead, but soft when compared with steel**; *and so forth.*

III. THE HARDEST BODY KNOWN

Here is a piece of glass. You have seen that I cannot cut it with this knife. I could not cut it with the sharpest of steel tools. I can scratch it with this sharp flint. The glazier cuts the glass easily enough when he is putting a new pane in the window. But he does it with his diamond.

Diamond is the only substance that will cut glass. In fact, it will scratch or cut every other substance. It is therefore the hardest substance known.

If possible, show the children a glazier's diamond, and point out to them the little bit of something that looks like clear glass at the end. It is this which does the work of cutting.

Show how it is done.

IV BRITTLE AND TOUGH

Set one of the children to try and break a piece of iron (not cast iron), cork, or hard wood, by beating them with a hammer. Next let him do the same with a piece of glass, flint, or chalk.

What difference does he find? He can break the glass, the flint, and the chalk easily.

We say they are **brittle bodies.**

He cannot break the iron, the cork, or the piece of hard wood.

These are called **tough bodies.**

What happens when we drop a tea-cup or a glass tumbler on the floor? They break into pieces.

Why is this? Because they are brittle.

Would the same thing happen if we threw our boot, this sixpence, or this india-rubber ball on the floor? No, they would not break, because leather, silver, and india-rubber are not brittle but tough.

Conclude by asking the children to name some tough and brittle bodies, and have them set down in two lists on the black-board as they are given.

Lesson IV

POROUS BODIES

I. Meaning of the word Porous

Place a large dry sponge in a saucer of water, so that all may see, and then call upon one of the children to come out and take away the sponge. This done, turn the saucer up and show that there is no water at all in it now.

What has become of the water? It is in the sponge.

See, I will squeeze it all out into the saucer again.

Let us try the same with this ball of lead.

Does the water leave the saucer and go into the lead as it did into the sponge? No.

Now look at the sponge and the lead, and see if you can tell me why the water passes into the one and not into the other.

There are little holes all over the sponge, but there are no holes in the lead.

Yes, and the holes are not only on the outside of the sponge, but all through it.

Cut a piece of it away and show the holes.

It is full of holes. These little holes are called **pores,** and because the sponge is full of holes we say that it is **porous.**

Porous means full of holes.

The sponge sucks up the water because it is porous, and the water fills up the little holes in it.

Here is a piece of bread. If I stand it in the saucer, with only a little water at the bottom, I shall soon find the bread wet all through. It will act just as the sponge did.

Look at the bread, and you will see that it too is porous. You can see the holes in it.

Illustrate further with a piece of pumice-stone, cane, soft wood, coke, charcoal, or any other substance ready to hand.

II. THE PORES ARE NOT ALWAYS TO BE SEEN

Here are two lumps of chalk. I am going to weigh them in these scales. I put one into each scale-pan. See, they are exactly the same weight; the scales are level.

Now I drop one of them into this basin of water, and leave it there for a minute or so.

That will do. I will now take it out, and put it in the scale again.

What happens? The scale goes down.

What does that show? That the chalk which I have taken out of the water is heavier than the piece in the other scale. It is heavier than it was before I put it into the water.

What makes it heavier? It has sucked up water out of the basin. Now it could not suck up water unless it were porous.

Take the dry piece of chalk, and see if you can find any pores in it such as we saw in the sponge. You cannot find any.

No, but I will show you that there are pores in the chalk.

Place the dry piece of chalk on a plate containing a little coloured water, and hold it before the class so that they may see the tiny threads of coloured liquid rising through the white substance.

The pores in the chalk are so small that we cannot see them, but we know now that they are there, because we saw the water rising in them from the plate.

Chalk, then, is a porous body.

The same experiment may now be shown with a piece of lump-sugar.

We cannot see the pores in the sugar, but we find that if we lay it on a wet surface, the lump becomes wet through in a short time; and if we use coloured water we can actually see the water gradually rise as we did in the chalk.

III. ABSORBENTS

Porous bodies, we have seen, have the power of sucking up water through their pores.

Now I want you to remember a long word which means the same as the words **suck up**.

The word is **absorb**. All porous bodies **absorb,** *i.e.* **suck up** water through their pores; and because they do this we call them **absorbents.**

Call attention to some common substances which are very useful to us only because they are porous *and* absorbent, e.g., *blotting-paper, because it* **sucks up** *or* **absorbs** *ink; sponge, because it* **sucks up** *water or other liquids and can hold them in its pores.*

Next show that some are equally useful to us because they are not porous and not absorbent.

1. What would be the use of a porous vessel for holding liquids? None; the liquids would all trickle through the pores of such a vessel and be lost. We therefore use glass, horn, silver, india-rubber, for this purpose, **because they are not porous.**

2. Why do we wear boots and shoes made of stout leather? **Because the leather is not porous, and does not absorb water.*** The leather therefore keeps our feet dry in wet weather.

These will be quite sufficient for the present stage. The subject will be taken up again as we proceed.

* N.B.—*This is more strictly true of india-rubber galoches—the india-rubber being absolutely non-porous.*

Lesson V

PLASTIC BODIES—A PIECE OF CLAY

I. Clay is a soft Mineral

Show one of the lumps of dry clay.

Who can tell me what this is? It is a piece of clay.

Where did it come from? It was dug out of the ground.

All have seen clay turned up wherever any digging is going on, for it is found almost everywhere.

Make the class tell where they have met with clay.

We have one common name for all substances which we get out of the earth in this way. **We call them minerals.**

Clay is a mineral.

Break up the lump into small pieces, and distribute round the class. Set the children to examine them, and make them tell what they can about this substance.

How easily I broke the lump up into small pieces with my fingers.

Let them dig pieces out with their finger-nails, with their pencils, or with a knife.

What does this teach us about the clay? It is soft. We call clay a soft mineral.

II. Colour

The pieces they have in their hands are probably of a greyish-brown or slate colour. Tell that all clay is not the *same colour. If possible, have some pieces of various kinds at hand, and show that some are black-blue, reddish-brown, yellow.*

Clay in its purest form is white. The rougher kinds, such as those we have before us now, get their colours from other things which lie near them in the ground.

III. DRY CLAY

Take the lump of dry clay—scrape it with a knife, and show that it crumbles to pieces readily. Drop a piece of it on the table, or strike it with a hammer. It breaks easily. Try the same with the moist clay. Does that break? No.

What do we say about things which break easily? We say that they are **brittle. Dry clay is a brittle substance.**

Now place the dry lump of clay on the table, and let a few drops of water trickle on it. Let one of the class come out and look for the water.

Where is the water? It has disappeared. It is not on the table, for the table is dry. The clay has sucked it up.

Let fall some more drops, and watch again.

The result is the same. The water is in the clay. What is the word that means "**to suck up water**"? The word is **absorb.**

And what do we say of bodies that do absorb water? We call them **absorbents. Dry clay is absorbent.**

Why are certain bodies absorbents? **Because they are porous.**

What does this mean? Full of pores or holes.

Look at the piece of clay, and tell me whether you can see any pores or holes in it? No.

Is it porous then? Yes, it is, although we cannot see the pores.

How do we know? Because it absorbs or sucks up the water through its pores. **Dry clay always sucks up water in this way.**

Illustrate its greediness for water by letting the children put the piece of dry clay to their tongue, and explain what happens.

The clay sticks to the tongue. Why is this? The clay robs the tongue of all the moisture it can get, and is still greedily sucking to get more.

Our piece of clay on the table will absorb a large quantity of water. Indeed, it will drink it in until all its pores are quite full; but after that it will not take another drop.

Show this by pouring water, little by little, on the clay until it is quite wet. When this is the case call upon the children to explain what they observe.

The water now no longer passes into the clay, but rolls off it on to the table. The clay can hold no more, it is quite full.

Without calling special attention to the fact, contrive to leave a deep round hollow in the top of the clay, and let some of the water collect in this hollow.

Now call attention to the water as it stands in the hole. The water cannot pass through the clay now, for moist clay is not porous like dry clay. The hole forms a sort of basin, and will hold the water.

When men are going to make a pond, or a canal, they always line the bottom and sides with clay to prevent the water from running away by soaking through the earth.

IV. Moist Clay is plastic

Now let one of the children take a piece of moist clay in one hand, and a sponge, some loose wool, or a silk handkerchief rolled up like a ball, in the other.

We have been told to call all these substances soft, and so they are. Let us see what else we can find out about the clay.

Close both hands so as to squeeze up the clay and the silk handkerchief. Now open the hands wide. What happens? The silk handkerchief remains as it was, but the clay has been moulded to the shape of the closed hand.

Boys often get a piece of newly-dug clay and amuse themselves with it for a long time.

What do they do with it? They make it up into all sorts of things.

Give the children some pieces of moist clay and set them to make some common things.

First let them make a brick, then break up their brick, and flatten their clay into a sort of plate. Let the plate pass into a basin, the basin into a flower-pot, and so on, the teacher taking up the task where individuals fail.

The clay will take any shape we please, and will keep it as long as we wish.

Substances that can be moulded in this way into any shape are said to be **plastic.**

The dry clay is brittle and falls to pieces; but as soon as it is moistened with water, I can knead and mould it up. It is plastic again.

Call attention to mother making dough for a pie. The flour is dry and powdery, but when she pours water on it and works it up she makes a substance which she can mould into any shape she pleases. She sometimes makes twists and leaves of the dough to make the pie look nice. **She can do all this because dough is plastic.**

Lesson VI

CLAY—ITS USES

I. Why Clay is useful

Clay in its natural state—that is, as it is dug out of the earth—is a soft, plastic substance. It is this that makes it so useful.

Make the class show that they understand clearly what is meant by the term **plastic.**

The bricks for building our houses, the tiles for roofing them, the drain-pipes for carrying off waste, the flower-pots for our gardens, are all made of clay; and so are all our earthenware articles (plates and dishes, basins and jugs) and our china cups and saucers.

Let the class tell the meaning of the term **earthenware,** *and why this name is given.*

II. HOW EARTHENWARE IS MADE

Bricks, tiles, drain-pipes, and flower-pots are all made of common clay. Earthenware articles are made of better and purer clay, nearly white, and the clay is mixed with finely-powdered flints that have been burnt in a red-hot furnace. Our china cups and saucers and ornaments are made of the purest and whitest clay that is to be found.

All the articles, after being formed and moulded into the proper shape, have to be put into a very hot oven and baked. When they are taken out of the oven they are hard and firm, and will always keep their shape.

We cannot alter the shape of a plate or jug without breaking it.

III. CHANGES AFTER BAKING

1. *Drop a piece of soft clay on the floor. It is tough and does not break.*

What would happen if I were to drop this cup in the same way. It would break in pieces. **The baking has made the clay hard and very brittle.**

2. I have here a piece of clay and a piece of broken flower-pot which have been soaking in water for some time. Look at the clay. I can mould it up into any form I wish, **because it is plastic.**

Now let us try to do the same with the piece of flower-pot. Can I mould it? No. I cannot alter its shape. It is **not plastic** now. It will never be plastic again. **The baking has robbed the clay of its plastic properties.**

3. *Mould a rough basin again out of a piece of moist clay, and fill it with water.*

Why does not the water run out? Because moist clay **is not porous.**

Now I have here a piece of common brick, which I will put into this basin of water.

See, I will fill the basin with water to the brim.

After letting it remain for a minute or so, call one of the children to the front, and let him tell what he sees. Some of the water has gone.

What has become of it? It has not been spilt on the floor. Who can tell?

It has been sucked up by the brick.

Then, if the brick has sucked up the water it must be—? **Porous.**

Yes, the brick is porous, but the moist clay was not porous. **The baking has made the clay porous.**

Explain that when the brick is taken out of the basin the water will drain out of it, and it will again become dry. The water will not stand in the brick and make it soft again. The brick can never become soft and plastic any more.

Now see what I have here.

Show some pieces of **red ballast.** *Tell that they are simply rough pieces of clay which have been burnt until they were red hot. Strike them with a hammer and show that they are very hard and brittle.*

The ballast is very largely used for making roads and paths.

Let us see why. Clay, as we know, becomes porous after it is baked. It absorbs water, but the water simply runs through its pores, and does not stand in it and make it soft.

When therefore a road is made of this burnt clay or ballast, the rain which falls merely trickles through its pores and sinks down into the ground underneath. **The ballast does not hold the water.** It always remains hard, dry, and porous.

IV. Porous Pipes, Earthenware, and China would be useless

It is all very well for our bricks, ballast, and flower-pots to be porous. We want the water that gets into them to drain out. But what about our drain-pipes, basins, pans, jugs, and cups and saucers? These have all to hold water or some other liquid. Would they be of any use to us if the liquids in them were always trickling out through their pores? No.

And yet all these things when they are taken out of the oven are porous just like the flower-pot.

Show, if possible, an unglazed cup or other vessel. Such a vessel as this would not hold water without some of it oozing through. Now show a finished cup and make the class tell the difference. This one is smooth and shiny like glass, but the first one was rough.

Explain that after the articles have been baked they are set aside to cool, and then dipped into a glazing mixture and baked again.

This glazing mixture is so called because after the second baking it covers the cup or other vessels all over with a coating like glass. **This coating is not porous.** It will not allow liquids to pass through.

The glazing mixture for drain-pipes is mostly made of salt; that for china ware is composed of granite, white lead, and broken glass. We shall learn how this is done in a later lesson.

Our plates and dishes, cups and saucers, are made pretty with pictures and colours. These are put on after the first glazing, and the vessels are baked again.

Lesson VII

PLASTIC BODIES—A PIECE OF PUTTY

In the last lesson we dealt with an earthy mineral substance—clay, and we know that clay in its natural state is a **plastic body.** *We are now going to talk about a new substance, which is also very useful to us because it is* **plastic.**

Before proceeding with the new subject, however, it will be *well to carefully brush up old facts by a rapid recapitulation of what has already been taught.*

I. ITS PROPERTIES

Show the piece of putty.

What have I in my hand? Some putty.

Did you ever see any one using putty? What was he doing with it? He was putting a new pane of glass into the window.

What do we call a man who does this work? A glazier. Yes, putty is used by a glazier for fixing the glass panes in the windows.

Break up the putty, and hand the pieces round the class for test and examination.

1. **Putty is a soft substance.**

Let the class find this out for themselves by scraping it with the nail, and by breaking it in pieces with the fingers.

Now let one of the children try and scrape off some of the putty round a window-pane.

Can you scrape off any of it? No; it is hard.

The putty round the window-pane is very hard indeed; as hard—or harder—than the wood itself.

It is this property **of becoming gradually hard** which makes putty useful to the glazier. The piece of putty lying in front of each one now would also become hard, almost as hard as stone, if it were left standing for some time.

Show a piece which has been allowed to stand and harden.

2. **Putty is plastic.**

The children just now broke up their putty into little bits. Let them next take the little pieces in their hands, and knead them up again into one piece. Show them that **they can mould it** *into any shape they please, and that it will keep whatever shape is given to it.*

What shall we say, therefore, about the putty? It is **plastic.**

3. **Putty is waterproof.**

Mould a piece of putty into the form of a little cup, and fill it with water. Ask the class to tell what they observe.

The water **stands in the cup,** as it stood in the cup of soft clay. It cannot run through the putty, because the putty **is not absorbent.** If I pour water on this lump of putty, it will not pass through, but will run off it. **It is waterproof.**

4. *As the children knead up their putty they will find a difficulty in handling it, because* **it is very sticky** *and clings to the fingers.*

It is **this power of sticking fast** which enables it to hold the glass firmly in the wooden frame.

N.B.—*It will be sufficient to mention the fact now, without dilating upon the name of the property. Adhesive bodies will come later on.*

We have learnt, then, that when the glazier presses the putty all round the pane, and moulds it with his knife into the required shape, he knows—

(*a*) That although it is **very soft and plastic** now, it will gradually become **very hard indeed.**

(*b*) That whatever **shape** he gives it now, **it will always keep.**

(*c*) That as it hardens it will become more and more **waterproof.**

(*d*) That it will **stick fast** to both glass and frame, and so hold the pane securely.

II. WHAT PUTTY IS MADE OF

Putty is not found in a natural state, as clay is. It is made of other substances. The two substances of which it is made are **whiting** and **linseed-oil.**

Who has seen the whiting at home, that mother uses to clean and brighten the tins? Is this anything like it?

Show the cake of whiting. This whiting is really finely prepared chalk.

Lesson VIII

PLASTIC BODIES—PUTTY

We learned in our last lesson that putty is not a natural substance found in the earth like clay, but that it is made from two other substances.

What are they ? Whiting and linseed-oil.

We will now find out how putty is made.

I. Chalk

Show some pieces of chalk, and lead the class, by their own observation, to tell something about its qualities.

(*a*) As compared with a stone, it is **a soft substance,** and can be **scraped** with a knife.

(*b*) As we scrape it, some of the white particles readily fall away. This is what makes chalk so useful for writing on the blackboard, for the least touch will leave a trace.

(*c*) *Put some of the chalk in water, and break and stir it up.*

It makes a **white milky fluid.**

By and by the chalk will settle at the bottom, and the water may be poured off. We might take out that which settles at the bottom, and dry it, and then we should have **a cake of whiting.** This is how the cakes of whiting we see at home are made.

(*d*) The lumps of chalk which we have before us were dug out of the earth just as we see them now. Chalk is an **earthy** or **mineral** substance. In some parts of England there are hills made up of nothing but chalk.

II. Linseed-Oil

Show the bottle of oil. The oil was prepared from the seeds of the flax plant—the same plant from which the linen was got to make our collars.

(*a*) *Spread a little of the oil very thinly on some flat surface. Let some of the children touch it with their finger and thumb and notice its* **sticky** (*in addition to its oily*) **nature.**

If it is left to stand, spread out to the air like that, **it will rapidly dry.**

Compare with a non-drying oil, e.g. *olive-oil.*

(*b*) *Pour some water over the oiled surface, and make the class tell what happens.*

The water will not penetrate it, but simply runs off. It is the oil which makes putty **waterproof.**

The chalk mixed with water, as we saw it just now in the cake of whiting, although it formed for the time a **plastic substance,** which could be readily moulded into any shape we please, would have remained **soft** and **brittle**; while water, instead of running off it, would have been sucked up by it.

Illustrate with a cake of whiting, letting the water trickle on it, until it falls to pieces.

It is the **hardening, drying,** and **waterproof nature** of the linseed-oil that makes putty useful.

III. How it is made

The preparation of putty can be best shown in the practical way before the class.

Slightly warm a quantity of linseed-oil in a vessel, and gradually add to it some well-dried, finely-powdered and sifted whiting, gently stirring the whole with a stick meantime.

As it forms into a solid mass, take it out of the vessel, and first beat it on the table, with a stick or mallet, and then knead it well with the hands, until it becomes uniformly soft and plastic.

Lesson IX

PLASTIC BODIES—GUTTA PERCHA

We are now going to deal with another substance remarkable for its plastic properties, a substance which owes its plasticity, not *like the clay, to water, nor like the putty, to oil, but simply to the action of heat. The class should first be made, therefore, to tell, by a few brief questions, the leading facts of the preceding lessons.*

I. INTRODUCTION

Sometimes, in the bad winter weather, I have my boots soled, not with leather, but with some other substance. Does any one know what it is called? See, I have a sheet of it here; and here are some pieces for you to examine for yourselves.

Tell its name, and write it on the blackboard.

II. PROPERTIES

Pass some of the pieces round the class, and put the rest in the hot water. Let the children proceed to examine for themselves.

Make them tell that it is a smooth, hard, brown, leathery substance, and that it has a peculiar smell.

1. *Take the sheet, and show that although you can bend it easily, it is impossible to tear it across. It is exceedingly* **tough and strong.**

Show that it may be easily cut, however, with a knife.

2. *Hold a piece in the flame of the gas, and show that* **it soon takes fire** *and burns with a white flame, giving off a powerful smell and a great deal of black smoke.*

3. *Take the pieces out of the hot water, and distribute them among the children, making them tell what change has taken place.*

The gutta percha has become soft in the hot water.

Set them to knead and work it up in their fingers. They will see that they can now mould the piece into any shape they please, and that it will retain the shape.

The hot water has made the gutta percha plastic. In a short time it will cool, and as it cools it will **harden** again.

4. *Mould one of the pieces into a sort of cup, purposely making the sides of the cup as thin as possible. Show, by pouring some water into the cup, that the* **gutta percha is waterproof.**

5. *Show some pieces of gutta percha and some pieces of iron which have been allowed to stand for some days in a damp place, and let the class note the difference.*

The iron is corroded with rust, but the gutta percha is uninjured. **Gutta percha is not injured by damp.**

III. Its Uses

Let the uses follow naturally from the properties.

1. We have already mentioned the soles of boots and shoes. Why is it so admirably suited for this?

Elicit step by step.

What happened when we put the piece of gutta percha near the flame?

Be careful, therefore, not to put your gutta-percha soled boots near the fire.

2. Gutta percha is also made into bottles, trays, cups, inkstands, and pipes for holding gas and water. Why? Into walking-sticks, whistles, toy-whips, picture frames. Why?

Note that it is so very strong that it is well fitted for making things for rough usage; but it cannot stand a warm temperature.

3. In its plastic state it is flattened between rollers into thin waterproof sheeting.

Help the class to name some of the uses to which this is put.

IV. What it is

It is time now that we learnt what this useful substance is, and where it comes from. Gutta percha comes from a tree which grows in the very hot parts of the world.

It is a very tall tree, and bears large oval, leathery leaves, green on the upper surface and a rich yellow below.

Show a picture of the tree.

The gutta percha comes from neither the wood of the tree, nor from its fine leaves, but **from the sap or juice** in the stem.

If a hole is made in the tree, **a thick milky juice** flows out, **hardening rapidly in the air.**

V. HOW IT IS OBTAINED

Every year as the seasons come round, men go through the forests, and mark the trees that are best suited for their purpose. These they cut down.

They then bore holes in the stem in different places, and the **milky sap oozes out** and is caught in vessels as it flows. As it reaches the air it soon hardens into a rough, shapeless mass, but is very much mixed with dirt and rubbish.

In this state the gutta percha would be useless. It must be purified. This is done by cutting the lump into very thin shreds and softening it in hot water, so that the dirt may be all picked out.

When this has been done, the shreds are all softened again in hot water and kneaded into a compact mass ready for making up into articles of use.

Lesson X

SOLUBLE SUBSTANCES

I. THE MEANING OF SOLUBLE

SHOW a lump of common table-salt.

Who can tell what this is? How could you make sure that it is really salt, and not sugar? By tasting it.

Now taste this and say which it is. It is salt.

Break off a piece of the salt, and put it into a glass of water. Stir the water for a little while, till the whole of the salt has disappeared. Now hand the glass round.

You all saw me put the piece of salt in the water. Is it there now? Yes.

How do you know it is there? Can you see it? No, we cannot see the salt in the water now.

I can soon prove to you that it is there.

Let one of the children come to the front and sip a little of the water out of the glass.

Now tell us whether the salt is in the water or not. It is.

Why are you sure of it? Because we can taste it.

Now then we know that the salt is in the water. Why cannot we see it? What has become of it?

Perhaps you will tell me it is melted. Let us see.

Who can tell me what happened when I put the piece of wax in the spoon and held it over the lamp? The solid wax was changed into a liquid. **I melted the wax; melting simply means changing the solid into a liquid.**

Repeat the melting process now, and show them that they can see the liquid wax in the spoon although they cannot see the salt in the water.

Let us try to do the same thing with some salt. Put a piece of salt into an iron spoon and hold it over the spirit-lamp.

Does it melt? No, it still remains the same solid substance it was when I put it into the spoon.

N.B.—*Salt can be melted (that is changed from a solid into a liquid), but it is very difficult, and requires great heat.*

Salt then is not melted when put into water.

Place another piece of salt on a plate or a saucer, and slowly and gently let a little water drop on it. Call upon the class to tell what they observe.

What becomes of the water? The salt absorbs it. What can we say about the salt because it absorbs water? **It is absorbent.**

It is well to lose no opportunity of calling up in this way facts that have already been taught.

Continue to pour water on the salt, and show that by degrees *the little particles or grains of which it is composed become loosened and separate from each other, the whole falling in a heap on the plate.*

Take up the heap of wet salt now, and put it as we did the other in a glass of warm water.

At first it falls to the bottom of the glass, but as we stir it, it gradually disappears, and we know that it is there, only by tasting the water. The fact is, the little grains of salt, as we saw them on the plate, are no sooner put into water than they break up again and again into such very tiny particles that they cannot be seen; but they become more and more loosened from each other and scatter themselves all through the water.

Now I want you to try and remember three hard words which mean all I have been showing you.

1. Because the little grains of salt become loosened from each other in this way when put into water **we say that they dissolve. To dissolve means to loosen or separate.**

2. Because the salt dissolves in the water **we say that it is a soluble substance.**

3. The water which contains the dissolved salt is said to be **a solution of salt.**

The same experiments may be performed with sugar, gum, soda, alum, lime, or any other substance available.

II. ALL SUBSTANCES ARE NOT SOLUBLE

Put some broken flints, bits of glass, wood, chalk, iron, etc., into water, one by one, and show that they do not dissolve.

Call upon the class to name some of the substances which dissolve, and others which do not dissolve in water.

Those things which do not dissolve when put into water are said to be **insoluble. The word insoluble means not soluble—anything which will not dissolve.**

Lesson XI

SOLUBLE SUBSTANCES

I. BRINE, AND HOW TO GET THE SALT FROM IT

MAKE a very strong brine, calling upon the class to explain as you proceed.

Here is a lump of salt, tell me what will happen when I put it into a glass of water. **It will dissolve.**

What does that mean? It will break up into very small particles, so exceedingly fine that we cannot see them in the water.

What have we got in the glass now? **A solution of salt.**

Let one of the children dip his finger into it and taste it.

We call it **Brine.**

Now we will put some of the solution into this tin dish, and let it boil over the lamp. See what takes place. The water in the dish soon boils and we see it flying off in clouds of steam.

Let the boiling continue until all the water has disappeared in steam. Explain that nothing but the water itself can pass off as steam; whatever is dissolved in the water will be left behind.

What have we then left in the dish? The **solid salt which we put into the water at first is there.** We will take it out and test it for ourselves as soon as it is cool.

While it is cooling, evaporate some ordinary water in another dish, and show that there is, in this case, nothing left behind.

Now scrape the salt out of the first dish, and show that all this solid matter was held in solution in the water, although we could not see it.

Let the children take it in their hands, examine it, and taste it, and see that it is really salt.

We have recovered the salt from the solution by boiling.

Make a syrup with some sugar and water, and treat it in the same way, showing that sugar and other soluble substances, as well as salt, can be got back from the water which holds them in solution.

N.B.—*Of course the sugar left behind after the boiling will be in the form of a toffy, and not in separate grains.*

II. SALT GOT FROM SEA-WATER

Who can tell me where we should find a very great body of salt water, so great that we could ride on it in a big ship for many weeks? In the sea. Yes, the water in the sea is very salt, as you would soon find by tasting it.

But if I were to show you a glass full of sea-water, you would not be able to see the salt in it.

Why is this? Because the salt is held in solution. **It is dissolved in the water.**

Salt can be obtained from sea-water just as we got it from the brine, by boiling away the water and leaving the salt behind.

III. TABLE-SALT

The salt which we use every day—this lump of white salt I have here—was not obtained from sea-water. Let me tell you how we got it.

Deep down in the earth there are **great solid beds of salt** stretching for many miles; not clean, white, crumbling salt, such as this which we have here, but a different-looking substance altogether. (*Show a lump of rock-salt.*)

See, it looks like a piece of pinkish-brown stone, and is smooth and shiny. **We call it rock-salt, because it is like rock, or stone.**

How could we prove that it is salt? By tasting it.

Let us see what happens if we put a piece of it into a glass of water. See, the lump is getting smaller and smaller, and will soon disappear altogether.

What has happened to it? **It has been dissolved,** and although we cannot see it, **it is in the water forming a solution.** (*Prove this by tasting the water.*)

We will next pour the solution into the tin dish, as we did before, and let it boil over the lamp.

When all the water has been driven off in steam, show the class that we have left in the dish a heap of little white grains.

Let the children test these in the usual way, by tasting them.

What has the boiling left behind in the pan? Grains of salt.

Now let us go back and think of those great beds of rock-salt which stretch for miles underground.

What would happen if water were always soaking through these beds of rock-salt? The water would **dissolve some of the salt and make brine.**

Well this is just what does happen. You know that every time it rains some of the rain soaks into the ground.

Now whenever it soaks into a place where there are any beds of salt underground, **it always dissolves some of the salt as it soaks through, and becomes brine.**

In order to get the brine, men bore a hole through the ground into the bed of salt, and put a long pipe down the hole. The brine runs into this pipe, and then they pump it up.

The salt is got from the brine just as we did it in our little dish, by boiling away all the water and leaving the salt behind, only they boil the brine in great shallow pans as big as a room.

In some places people get the solid rock-salt, instead of pumping up brine and boiling it. To do this they have to dig great deep holes in the earth, which we call mines.

Lesson XII

SUGAR

I. Its Uses

Show some specimens of moist and loaf sugar.

Now you all know what I have here. I want you to think of some of the ways in which we use sugar.

Let the children mention as many uses as they can, the teacher adding to the list when necessary.

II. WHAT SUGAR IS

Take a piece of the stem of some soft, herbaceous plant and pull it to pieces, or beat it with a hammer, and call attention to the sap or juice in it.

Every plant and every tree that grows contains **sap or juice.** The juices of some plants are very sweet and contain sugar.

Why do we like a ripe apple, pear, or plum? Because it is sweet. It is sweet because it contains sugar. We might get sugar out of it if we wished. But we do not use our delicious fruits to provide us with the sugar we need. Why not?

Lead the class to tell the reason.

Nearly all the sugar we use is made from a plant called the sugar-cane. Let us learn something about this plant.

III. THE SUGAR-CANE

Show a picture of the plant, and explain that it is not at all like any of the plants or trees which we see growing here.

It does not grow in this country, but only in very hot countries far away from us.

It is a very large kind of grass which grows from eight to twenty feet high. It has a thick, stout stem, about two inches across, **filled with very sweet juice.**

See that the children form a correct notion of these measurements, by comparing them with things about them.

When the sugar-cane is fully grown, it is very beautiful, for it bears at the top a large bunch of handsome feathery flowers of a pretty rose colour.

IV. HOW THE SUGAR IS OBTAINED

1. **How we get the juice.**—The sugar-cane ripens about March, and it is then that the beautiful flowers begin

to show. This is the time to get the juice. The ripe canes are cut down, and divided into short lengths. They are then carried to a mill, where they are crushed between large iron rollers. This crushing presses all the juice out of them, and it flows into great pans placed under the rollers. **It is very sweet and very sticky.**

2. **How we get the sugar from the juice.** Now tell me what happened in our last lesson when we boiled the syrup and the brine in the shallow pans. The water was driven off, and we had **the sugar** and **the salt** left behind.

This will help you to understand how the sugar is obtained from the juice of the cane.

The juice is put into large, shallow, copper pans and boiled. As it boils, the water passes off in steam, and the liquor becomes thick.

When it has boiled long enough, it is turned out into large open pans and left to cool. **As it cools it forms into solid grains.**

Show some coarse, moist sugar.

In this state it is called **raw, or moist sugar,** and it is placed in large casks with a number of holes at the bottom.

Some of the juice does not form into solid grains of sugar, but still remains a **thick, brown liquid.** This liquid gradually drains through the holes into vessels placed beneath. It is called **treacle, or molasses.**

V. LOAF-SUGAR

Let the class examine and compare moist and loaf sugar.

The one is of a yellowish-brown colour, and consists of separate grains; the other is pure white, and in one solid, sparkling lump. Loaf-sugar is made from moist sugar. We will see how it is done.

Some raw or moist sugar is dissolved in warm water, and a little lime is added to the solution.

The liquor is then poured into bags made of thick folds of woollen cloth.

Show a bag made of some loose kind of cloth.

Now what would happen if I were to pour water into the bag? It would gradually trickle through the cloth, and fall in drops into the basin.

Then if the water can trickle through in this way, what can you tell me about the nature of the cloth? **It is porous.**

Now instead of putting clean water into our bag, I am going to fill it with muddy water. See what takes place. The water trickles through the pores of the cloth, but it is no longer thick and muddy as it was when I put it into the bag, **it is much clearer.**

The pores of the cloth are too small to allow the particles of mud to pass through, and **they are left behind in the bag.**

The cloth forms **a strainer,** or as we sometimes call it, **a filter.** It allows the water to strain or run through, but keeps the mud behind. We shall learn more about filters by and by.

The thick woollen bag into which the solution of sugar is put acts just in the same way. **It becomes a filter.**

The liquor which passes through the cloth, although still brown, is quite clear, and has left many of its impurities behind in the bag.

The next business is to get rid of the brown colour. This is done by making the liquor filter through a layer of charcoal made of bones.

Charcoal, you know, is **a very porous substance.** When the liquor has passed through the charcoal, it is quite colourless. **All its brown colour is left behind.**

The colourless liquid is then put into large copper pans and boiled. The boiling drives off the steam, and **the liquor gradually becomes thicker.**

When it has boiled long enough, the liquid is poured into **moulds** and left to cool gradually. As it cools, **it**

forms into small grains which fasten themselves to one another and so form **a solid mass.**

Some of the liquor will not form into grains, but runs through and becomes **golden syrup.**

When the mass of white sugar is taken out of the mould, it forms **a hard, solid loaf.**

Lesson XIII

BURNING

I. SOME SUBSTANCES WHICH BURN

HOLD in the flame of a spirit-lamp with a small pair of tongs the following substances, and call upon the class to note what takes place in each case—a piece of calico and a piece of cloth or silk; a thin stick of wood and a piece of whalebone; a piece of coal and a piece of coke or charcoal; a sheet of paper and a piece of thin leather.

All these substances burn, but they do not all burn in the same way. Some of them blaze up into a fierce flame; some of them do not flame at all, but glow red hot and smoulder away; some of them send out smoke and smell while they burn.

One thing that we notice about all of them is that in every case they will burn until they are consumed.

Now I want you to learn two long words about burning.

All substances which burn are said to be **combustible.**

All those substances which burn with a flame are said to be **inflammable.**

Call upon the class now to mention all the **combustible** *substances they can think of, and lead them to tell whether they are* **inflammable** *or not.*

II. SUBSTANCES WHICH WILL NOT BURN

Now hold a piece of stone, clay, or chalk in the flame of the lamp, or put some pieces in the fire. How long must we wait till these burn away?

Let us leave them for a time while we put this poker in the fire.

Now what happens to the poker? It first gets warm, then hot, then very hot, and at last if we take it out of the fire we shall find that it is glowing bright red. We say it is red hot.

But is the poker any smaller? Has any of it been consumed or burned away?

We will put it aside to cool, and look at it presently.

If we take our chalk, stone, or clay out of the fire now, we shall find that they too have become very hot, but they are not consumed or burned away; neither has the poker. These things get hot in the fire, but are not consumed.

Suppose we have another hard word now. **Those substances which will not burn** are said to be **incombustible.**

III. SOME SUBSTANCES BURN MORE READILY THAN OTHERS

Hold, as before, in the flame of the lamp some ordinary wool and some loose cotton-wool; a piece of silk or cloth and a piece of calico, muslin, or linen; a piece of whalebone and a splinter of wood; a bunch of feathers and a wisp of hay or straw.

Lead the class to tell that the wool, silk, cloth, whalebone, feathers, and leather are all animal substances; the calico, muslin, linen, wood, hay, and straw are vegetable substances—the teacher assisting where they fail.

Now what have we noticed about these things burning? The animal substances burn with **more difficulty** than the vegetable.

Children, and especially little girls, should be very careful not to go near the fire. Their calico and muslin skirts **will readily catch fire** if brought into contact with a flame.

They should also be careful to keep the lamp and candle away from the window-curtains and the bed-hangings, **because these being made of cotton easily take fire.**

Place a piece of paper, a little hay or straw, and a piece of wood over the flame of the lamp, and show that the paper, hay, and straw take fire much more readily than the wood, and draw the same lessons of caution from these.

Next show some paraffin and benzoline. Draw from the children what they are, and what use we make of them. Tell that they are both **mineral oils. They are got from the earth.**

Put a little of each into tin saucers, and apply a lighted match.

The benzoline blazes up in an instant, showing that it is **very highly inflammable**; the paraffin (although we know it is **combustible,** because we burn it in our lamps) **puts out the flame of the match** and **does not take fire itself.**

Benzoline is much more inflammable than paraffin. It is one of the most inflammable of common substances. Lamps containing this liquid should never be brought near a fire, and should always be trimmed in daylight.

Lesson XIV

COAL—ITS PROPERTIES

I. Introduction

In our last lesson we dealt with a great many substances that will burn. Who can tell me what we call all these things? **Combustible substances.**

And what do we call those which burn with a flame? **Inflammable substances.**

Now there are some substances which burn so well that we use them to make our fires, for cooking our food and warming our houses. **Such substances we call fuel.**

Tell me some things we use as fuel.

After the children have mentioned coal, coke, and wood, the teacher may show some specimens of **charcoal** *and* **peat,** *and tell that these substances also burn well and are sometimes used as fuel. Hold them in the flame of the spirit-lamp and show how they burn.*

We shall learn more about these in a later lesson. I want to talk now about the most useful of all these substances. Which one do you think that is? **Coal.**

Yes, let us see what we can learn about coal.

II. PROPERTIES

Show a lump of common coal, and lead the class to discover for themselves its qualities, in some such way as this.

Look at this piece of coal and try to tell me what you can find out about it.

First of all, what does it look like? **It is black and shiny.** It looks like a lump of **smooth, polished black stone.**

Call one of the children to the front and let him take it up and handle it. Lead him to tell that it is **a hard, heavy substance,** *and give his reasons for so calling it.*

This piece of iron is also a hard heavy substance.

Now take the hammer and strike the iron and the coal a smart blow, and tell me what you observe.

The coal **breaks easily in pieces,** but the iron does not break.

What do we say about substances that break easily? We say they are **brittle.** Coal then is **a very brittle substance.**

Now call attention to the boy's hands.

The blackness of the coal comes off when we touch it, and makes our hands and clothes dirty. What a black dirty-looking man the coal-heaver is when he brings the coal to our houses!

Hold a piece of coal in the flame of the spirit-lamp with a small pair of tongs, and let the class notice and tell exactly what takes place.

First **a puff of thick smoke** oozes out from the coal, then the coal itself **swells** up into **a soft mass,** and then it bursts into **a bright flame.** Soon the whole lump will be in a blaze. If we left it to burn, the blaze would gradually die down, the lump would get red hot, and throw out great heat. After a time the whole of the coal would be consumed or burned away, and nothing would be left but **some white ashes.**

We learn from this that **coal is very inflammable,** that **it burns until it is all consumed,** and that **it gives out great heat while burning.** This is why we use it for fuel.

III. Coal is a Mineral

Call attention to some of the specimen objects lying on the table.

Look at this piece, what is it? Clay.

Yes, and where did it come from? It was dug out of the earth.

Here is a piece of something else, which you have seen before, what is it? Rock-salt.

Where did this come from? It was dug out of the earth.

In this way proceed with the chalk, iron, lead, stone, slate, and so on to the lump of coal.

Where did this come from? **It was dug out of the ground.**

Yes, coal and all these substances we have before us were dug out of the ground; and because they were dug out of the ground we have a name for all of them. **We call them minerals.**

Coal, then, **is a mineral.** To get the coal, great deep pits or holes have to be dug in the ground.

We call the pits, **mines**; and we call the men who dig the coal, **miners.**

Here I have a carrot and a potato. They were dug out of the ground. Do we call them minerals too? No. The carrot and the potato live and grow, **minerals do not live or grow.**

Many of the minerals, such as the stone, the clay, the slate, the iron, the lead, the marble, and the granite, we use to build our houses, churches, schools, and other buildings. Some of them we could not use for this purpose.

Why, for example, could we not use rock-salt in this way? It is not only very brittle, but a heavy shower of rain would wash it away, because it is **a very soluble substance.**

Now in the same way people never use coal for building their houses. Who can tell me why?

Lead the class to think again of its brittleness, its inflammability, and the ease with which the blackness rubs off.

Picture some boys living in a house made of coal. Their house would be constantly crumbling to pieces, they and their clothes would always be black and dirty, and they would be in constant danger of fire.

But this brittleness is a highly useful quality in coal, when we want it for fuel. We can easily break up our coal into pieces just fit to make our fires; or we can crack the burning lump with the poker, and make it fall to pieces if we wish.

Lesson XV

COAL—ITS USES

I. What Coal is

In our last lesson we learnt that coal is a mineral. What does that mean? Tell me the name of some other minerals that are got from underground.

Now coal, although we call it a mineral, is not a mineral in the same sense as the clay, iron, or lead.

Coal was not always in the ground, as the other minerals have been. **It was made** in a wonderful way **from trees and plants** that grew many thousands of years ago.

Some of the forests that grew on the earth in those days sunk down and got buried deep in the ground, where they have been hidden away ever since. During this time **they have been changing from wood and leaves and roots and branches into a new kind of mineral substance** which we now dig up and call **coal.**

I cannot make little boys like you understand how this wonderful change took place; but we know what must have happened, because pieces of coal are sometimes dug up having **the shape of the trunk, branches,** and **bark** of the **trees,** and from the portions we can even form a good idea of the kind of trees and other plants that grew in the forests of those distant days. Here is a picture of some of them.

We often find pieces of coal with **the shape of leaves** and **ferns** marked upon them.

Show a piece if possible.

II. Kinds of Coal

Here are several kinds of coal.

1. That which I showed you in our last lesson was the common coal, such as we burn in our houses. You know that it blacks our fingers if we handle it, and if I throw a piece on the fire it will burn with flame and smoke, and cake together into a solid mass as it burns.

2. Here is a piece of another sort. It is called **cannel coal** or **candle coal,** because it burns with **a very bright flame.**

Take it in your hand. See, it does not soil your fingers as the common coal does. It is **very hard** and **smooth** and **can be polished** to look like **black marble.** People sometimes make inkstands and other articles of it.

Hold a piece of it in the flame of a spirit-lamp, to show how it burns.

3. Here is another kind, **harder and closer** than either of the others.

Prove its hardness by breaking it with the hammer.

We call it **anthracite,** a long word, which simply means coal. **It is called stone coal,** because it is hard.

If I put a piece of this in the fire, or hold it in the gas or flame of the spirit-lamp, it will burn, but without either flame or smoke, and it does not cake into a cinder.

It is sometimes called **blind coal,** because **it burns without flame.** This coal will not burn in our grates, but it does well in closed furnaces, where it gives out great heat and burns for a long time.

4. **Jet** is a kind of coal. (*Show a specimen and tell of its use for making ornaments, etc.*)

III. Uses

Of all the minerals, coal is the most valuable and most useful.

1. *Lead the children to mention the warming of our houses, the drying of our wet clothes, the cooking of food.*

2. Now who has seen a big steam-engine at work? What sets the engine in motion? **Steam.** Where did the steam come from? It was made by boiling some water in great boilers. And what makes the water boil? **Great fires of coal.** Then coal really sets our great **steam-engines** at work.

Picture to the class factories all over the country doing different kinds of work. This work is mostly done by machines. The machines are made to move by engines: the coal sets the engine in motion, and so **coal does it all.**

Picture hundreds of railway trains dashing along and carrying people and goods every day by steam. **Coal does all this.**

Picture hundreds and thousands of immense ships on the sea, some loaded with good things for us from far-off lands, some *taking away to them other useful things from us. These ships go by steam.* **Coal makes the steam, and so does it all.**

I am now going to show you a little experiment to help you to find out something more about the uses of coal. I have here some small coal which I am going to put into the bowl of this long clay tobacco-pipe. See, the bowl is now nearly full. Here I have some soft clay.

Now I shall cover up the top of the bowl quite close with some of this clay. The next thing is to put the bowl of the pipe into the fire, and I want you to watch the other end of the pipe and see if you can find out what happens.

In a little time we shall see **some light-coloured smoke** coming out at the end of the pipe. Can you see it now? Yes.

Let us watch it still, until we see the bowl of the pipe get red hot. There! can you see any smoke coming now? No.

Now I will prove to you that although you can see nothing, yet there is really something coming out of the pipe. Notice what happens when I put this lighted match near the pipe. **A bright yellow flame** comes from it.

There is something really inflammable coming out of the pipe, and that something has been made from the coal which is burning in the bowl.

If we blow out the flame, we shall not see anything, but the lighted match will soon prove to us again that the same substance is still pouring out from the pipe.

Take the pipe out of the fire now and let it cool.

If I turn on this tap in the gas-pipe, we cannot see anything coming from the burner, but as soon as I bring a lighted match near, a bright flame is seen.

The substance which burns in our gas-pipe we call **gas,** and we in our little way **have been making some of the same gas** as that which is now coming from the burner.

All the gas which we use to light our houses and streets and shops **is made by burning coal.** Think what a vast quantity of coal must be burned every day in the **gas-works** to make enough gas to light our great town.

Our pipe is cool now. Let us break the bowl, and see what we have inside. Why, **it looks like a piece of cinder.**

What do you think it is? **It is coke.**

When the **coal** is burned in this way **to make gas,** the **cinders** which are left behind form another very useful substance called **coke.**

Lesson XVI

COAL—THE MINE

Show a good picture of a coal-mine.

I. Coal as it lies Underground

You can all tell me what coal is made of, and how it came to be buried underground.

I want next to show you how coal lies in the ground.

In the first place coal is not to be dug up everywhere, but only in certain places. The places are known as **coal-fields.**

If we were to dig a hole in the ground we should not find coal and the other minerals we have mentioned all mixed up together.

Most of the minerals are arranged in **layers** or **beds,** lying one upon the other, so that it would be impossible to get at one of them without digging through those above it.

Many little devices will suggest themselves to the teacher to make this arrangement clear to the class.

Coal then lies buried in the earth in beds or layers, and these beds stretch for many miles underground. We call the beds **seams of coal.**

Some of the beds or seams lie very deep in the ground, so deep that there may be as many as twenty or thirty other beds before we get down to the coal.

There may be several beds of coal, one below the other, but they are always separated by beds of clay, sandstone, or other rocks.

There is usually a **bed of clay** under the **coal-seam.** This was **the soil** in which **the coal-plants once grew.**

The coal-seams vary in **thickness.** Some of them are only a few inches in thickness, others are eight, ten, and even twenty or thirty feet in thickness.

II. How Coal is got

Boring.—When men want to dig for coal, the first thing to find out is whether there is any coal in the ground to dig for. They cannot see it, for it is buried deep in the earth. Let us see how they find out.

They bore a hole in the ground with long sharp steel chisels worked by machines. As the hole is bored it is lined with tubing, and so down the instrument goes working its way through one bed after another.

From time to time the chisel is pulled up and another instrument called **a wimble** is sent down the tube. When this is brought up, it brings up with it some of the materials which the chisel has been cutting away, and the men learn whether there is coal there or not.

III. Sinking the Shaft

When it is found that there is coal in the ground, **a shaft or pit** from ten to fifteen feet across is dug straight down into the earth. The sides of the **shaft** are lined with brickwork, iron, or wood, as the digging goes on. This is done to keep the sides from falling in, and also to prevent the water which is met with from oozing through and flowing into **the shaft.**

The men continue to dig down through sandstone, clay, and hard rocks, until at last they come to the coal-seam.

They very seldom reach the coal till they have dug **a hundred and fifty feet** down into the earth. Some **shafts** are no less than **one thousand eight hundred feet deep.**

NOTE.—*The teacher should be careful to impress these and all other measurements upon the children, by comparison with the measurements of some well-known objects.*

As the pit gets deeper and deeper, the men are let down to their work **in great cages,** which are lowered by machinery, and the clay and rocks which they dig up are raised in the same way.

IV. MINING

Imagine now the men to have reached the coal-seam. What is the next thing to be done? In what direction does the seam extend? The coal-seam stretches in a horizontal direction at the bottom of the shaft.

Therefore the men next set to work with pickaxes and shovels to dig out through the coal itself **broad, straight passages from twelve to fourteen feet wide.**

These are **the main roads.** From them other smaller passages are dug out, crossing and recrossing each other at right angles, like **the roads, streets, and lanes** in some underground town.

Wherever they dig they follow **the seam of coal,** so that all the material they dig out in the roads, streets, and lanes of this underground town is **coal.**

As they work they are careful not to remove all the coal. If they did, what do you think would happen? The roofs of their roads and passages would fall in upon them and crush them to death. They therefore leave enormous **blocks of coal** between the roads and passages; enough to support the earth above and prevent it falling in.

These blocks of coal form, as it were, the great blocks of buildings of their underground town, with **the roads and passages running between them.**

Lesson XVII

THE MINE AND ITS WORKERS

I. INTRODUCTION

WE are going to learn something more about coal and the coal-mine to-day; but before we commence the new lesson, I want you to answer me a few questions on what I have already told you.

How is coal found in the earth? In **beds, layers,** or **seams.**

What was the coal made of? It is the remains of **buried forests.**

What is the place called where coal is dug out of the earth? It is called **a mine.**

What is the pit or hole of the mine called? The **shaft.**

In what direction do the miners work after they reach the coal-seam? They dig out **roads or passages through the coal itself.**

II. THE HEWERS AND PUTTERS

The coal is cut away with pickaxe and shovel from the sides, roof, and floor of these underground passages by men called **hewers.**

Show a picture of the hewer at work, and tell of some of the hardships he must endure.

When the hewer has cut away a heap of coal, it is put into a little truck and pushed along the narrow passages by boys called **putters.** The putters take it in this way to one of the main roads. Here a number of trucks are chained together, and drawn along a little railway to the bottom of the shaft by horses.

In some mines there are several hundred men and from fifty to sixty horses always at work.

When the truck-loads of coal are brought to the bottom of the shaft, they are loaded on cages and drawn up to the surface of the earth, by means of a steam-engine.

After the seam has been well worked in this way, and nearly all the coal removed, the miners proceed to cut away the great blocks of coal, which they at first left standing to support the roofs of their passages. They always commence with the blocks farthest from the shaft.

While they are at work cutting away these blocks, they prop up the roof with great beams of timber to prevent it falling in. As soon as all the coal in the block is removed, the timbers are taken away, and the roof having no support falls in.

Let the class now tell why they always commence with the blocks farthest away from the shaft.

III. DANGERS OF THE MINE

Do you think you would like to work down in those mines? No.

Tell me one reason why you would not like it. It is always dark there.

Yes, it is always dark, because the sun cannot shine into those underground passages; and it is darker than the blackest night you ever saw.

This darkness will lead me to tell you about one of the most awful dangers the poor miners have to meet.

What did we get by burning coal in the tobacco-pipe? We got coal-gas, just like that which we use to light our houses and streets.

Down in the mine some of this gas is always escaping from the coal without any burning.

The miners call it **fire-damp.**

Now I am going to show you a little experiment, to help you to understand the danger of this fire-damp in the mine. I have here a soda-water bottle filled with a mixture of coal-gas and air. I am going to draw the cork and let out the gas near the flame of the spirit-lamp. As soon as I do this the gas will explode with a loud bang.

N.B.—*Great care is necessary with this experiment, as it is somewhat dangerous. The bottle should be held with a thick cloth, and at a distance from the class. The opportunity should be taken of warning the children how to act in case of an escape of gas into the room.*

Now let us go back to the mine. The gas escapes from the coal, and as it escapes it mingles with the air in the mine. The moment such a mixture of gas and air comes near a flame there will be an explosion, and perhaps hundreds of men will be killed.

Lesson XVIII

FIRE-DAMP IN THE MINE

I. Introduction

Recapitulate briefly the subject-matter of the previous lessons. Lead the children to tell of the dangers of the fire-damp in the mine. It explodes the moment it comes near a flame of any kind.

But it is all pitchy darkness in the mine, and the men cannot work in the dark. They must have a light of some kind. If they had a candle, or an ordinary lamp, the flame would catch the gas, and the awful explosion would take place.

II. The Davy Lamp

Every man who goes down into the mine is provided with a lamp, in which the light is surrounded with wire gauze, so that the bad gas and the flame cannot come together.

Every lamp is locked before it is taken down, and so all is quite safe. But sometimes one of the men disobeys orders and opens his lamp. If this is done, only for a moment, it is quite enough to cause a most terrible explosion, and perhaps all in the mine are killed.

Show a picture of the safety-lamp, or better still, a lamp itself, if possible.

Illustrate the principle of its action by holding a piece of wire gauze over a flame of a candle. The flame does not pass through the gauze. If there is gas in the mine some of it will pass through the gauze into the lamp, and burn there round the flame, but the flame itself cannot pass outside the wire gauze, and so the gas in the mine cannot take fire.

III. How the Mine is ventilated

We have seen how the miners prevent the bad gases from taking fire and exploding. But don't you think it would be better if they could get rid of the bad gas altogether from the mine?

What do I do when our room becomes close and stuffy and filled with bad air? I open the doors and windows to drive out the bad air and let fresh air into the room.

I **ventilate** the room. Let us see how the mine is ventilated.

A very simple little contrivance will make the whole thing quite clear to the children. A small wooden box and a couple of lamp-glasses will be all that is wanted.

Such a box could be easily obtained from a grocer or provision dealer. A baking-powder or blacking box would do admirably.

Have the lid removed, and cut a couple of round holes in the bottom, and near the ends, exactly the size to receive the two lamp glasses. See Fig. 1 *(Objects and other Illustrations required).*

Fit the glasses into the holes, and place a lighted taper under one of them.

As the taper burns, it will cause a current of heated air to pass up the glass. This up-current may be made quite clear by holding some pieces of burnt paper over the top of the glass.

The up-current in this glass causes a down-current in the other. This can be shown by holding a piece of smouldering rag or brown paper over the top of that glass. The current of air will draw the smoke down the glass with it.

In the mines the bad gases are removed and fresh air is supplied in a manner something like this.

The mine has two shafts at some distance from each other. At the bottom of one shaft a large fire is always kept burning. This makes the air very hot, and it rises and escapes through the mouth of the shaft. Other air, however, must take its place, and so there is a rush of air along the underground passages and galleries towards the bottom of the shaft. And where do you think this air comes from? It is fresh air from above ground, which passes down the second shaft. This fresh air, as it rushes along, mixes with the bad gases in the passages, and by the time it reaches the bottom of the shaft where the fire is burning, it has taken away their power of exploding. The heat from the fire then drives it up above the ground.

If time allowed, the teacher might tell of the lonely, dreary life of the little trappers who sit on guard at the swinging doors placed here and there along the passages to assist the flow of air in one direction towards the hot shaft.

Lesson XIX

FLEXIBLE AND ELASTIC SUBSTANCES

I. Introduction—Flexible

Bring two boys to the front, and let one take the poker in his hand, and the other a cane. Set them to try and bend the two things, the rest of the class watching the result. They will observe that the boy with the poker finds it impossible, with all his trying, to bend it so as to bring the two ends nearer to each other. The poker will not be bent. On the other hand they will see that the one with the cane finds it an easy matter to bend it, so as to bring the ends closer together.

Let them next try the same thing with a stick of wood and a piece of whalebone.

The whalebone bends easily, but the wood snaps in two rather than bend.

Because the cane and the whalebone bend easily without breaking we say that they are **flexible.**

Those substances which, like the poker, refuse to be bent are said to be **inflexible** or **rigid.**

Now who can remember how we describe bodies which break rather than bend? We say they are **brittle.**

The quality of flexibility may be further illustrated by some pieces of copper and iron wire, leather, etc.

Lead the class to tell—

1. That bars of iron, steel, and brass, great beams of timber and blocks of stone are rigid or inflexible.

2. That india-rubber, whalebone, leather, gutta percha, as well as thin strips of iron, steel, and brass are flexible.

II. ELASTIC

(*a*) **India-Rubber.**—*Show a thin strip of india-rubber. Let the children handle it and examine it. They know that it is a flexible substance, for they can bend it easily. Let them measure it with their ruler. It measures say six inches.*

Now set two boys to pull it. See, they have stretched it to almost double its length, for if we measured it now we should find it nearly twelve inches long, but it is not so thick as it was.

Make one of the boys now let go, and call upon the class to tell what happens.

It springs back and becomes short and thick again.

Yes; it not only becomes short and thick again, but it actually returns to the exact size and shape it had before it was stretched.

Because the india-rubber springs back to its former size and shape when it is stretched and let go, we say it is **elastic.**

Show by pulling a piece of flannel and a piece of woollen cloth, that these substances act in the same way as the india-rubber when we let go. They too are elastic.

(*b*) **Whalebone.**—*Make one of the children bend the piece of whalebone, and then let go with the one hand.*

What happens? The whalebone springs back to its former shape.

Before it was bent, and as soon as it sprang back again, it was straight. While it was bent, it formed a curve.

Because the whalebone springs back to its former shape, when we bend it and then let go, we say it is **elastic.**

Illustrate the same property with a cane, a watch-spring, or any piece of thin steel. These substances are also elastic, for they spring back to their former shape when we cease to bend them.

(c) **Sponge.**—*Let one of the children take the sponge in his hand and squeeze it.*

Make the class tell that as he squeezes he presses the sponge closer and closer together until it is much smaller than it was.

Now let him open his hand. What happens? The sponge immediately springs back to its former size and shape when he ceases to squeeze it.

Because the sponge springs back to its former size and shape when we squeeze it and then let go, we say it is **elastic.**

Show that the same property exists in an ordinary silk handkerchief, wool, hair, cork, etc.

Force a cork into a bottle. Show that the cork appears too large for the neck of the bottle, but that if you squeeze and press it you can get it in.

It goes in because it has been made smaller by squeezing.

Now pull it out again, and show that, as the pressure is removed, it has sprung back to its former size and shape.

We have examined three kinds of elastic substances—

1. The **india-rubber**, the **flannel**, and the **cloth** show that they are elastic only when they are stretched or made longer. They then try to get back again to the size and shape they had before they were stretched.

2. The **whalebone**, the **cane**, and the **watch-spring** show that they are elastic only when they are bent out of

shape. They try to get back to the shape they had before they were bent.

3. The **sponge,** the **cork,** the **silk handkerchief,** and the **wool** show that they are elastic when they are squeezed into a smaller bulk. They take the first opportunity of springing back to their former shape and size.

Call upon the class to name other substances which do not spring back, either when they are pulled, bent, or squeezed.

Pull this piece of lead. Bend it. Close your hand tightly on it. Is it elastic? No. Why not?

Show that the copper and iron-wire, although flexible, are not elastic. They do not spring back when we bend them.

Illustrate further, if time permits, with leather, clay, chalk, and paper.

Lesson XX

INDIA-RUBBER

I. PROPERTIES

THE object of this lesson will be to deal with the physical properties of india-rubber, and from these to lead up to its uses.

Make the class recapitulate by means of a few questions what they have already learned about this substance.

Look at this piece of india-rubber. I can bend it any way I wish. What can we say about it because of this? It is flexible. It bends easily.

Do you remember any other quality it has? It is elastic.

Why do we say that india-rubber is elastic? It springs back to its proper size and shape when it is stretched.

Now let one of the boys take a piece of india-rubber and a piece of leather and try to tear them. Can he do it? No, he finds the india-rubber and leather very hard to tear. He cannot tear them.

What do we say about bodies which are hard to tear?

We say that they are tough. **India-rubber and leather are tough.**

Hold a piece of india-rubber in the flame of the spirit-lamp and call upon the class to note that it burns with a white flame and gives off a strong smell and thick smoke.

What do we say about substances which burn with a flame? We say that they are inflammable. **India-rubber, then, is inflammable.**

Next show four test-tubes prepared and arranged before the commencement of the lesson. No. 1 *contains cold, No.* 2 *warm water, No.* 3 *turpentine, No.* 4 *naphtha. In each vessel is a piece of india-rubber. (Explain what these two liquids, turpentine and naphtha, are, and what they are commonly used for.)*

Let us look first at Nos. 1 and 2. Can you see the piece of india-rubber in them? Yes, they are both as they were when I put them in, except that the piece in the warm water has become softer than the other. If exposed to great heat, india-rubber becomes soft and pulpy.

Suppose I had put in some salt instead of the india-rubber, would you have seen the salt now? No. Why not? Because the salt is soluble. It dissolves in the water.

India-rubber then is insoluble. It will not dissolve in water.

But, wait a bit! Let us look at the pieces in the other tubes of turpentine and naphtha. They have swollen up; they have, in fact, begun to dissolve. The pieces have not disappeared, for it will take a long time for the whole of the india-rubber to dissolve.

Here, however, I have another bottle of naphtha in which I placed a piece of india-rubber a few weeks ago. Can you see it? No. Well, I have not taken it out.

You cannot see it because it has all dissolved in the naphtha.

India-rubber, then, although it is insoluble in water, is soluble in turpentine and naphtha.

Show a piece of india-rubber tubing and a boy's hollow india-

rubber ball. Fill them with water and show that none of the water runs out.

The india-rubber is waterproof.

One more thought about the elastic property of india-rubber.

If it is stretched out while warm and then made to cool suddenly before it has sprung back, india-rubber loses its elasticity and remains in the stretched state as long as it is kept cold. As soon as it is warmed it becomes elastic again, and springs back to its former size and shape.

Now let us see what we have learnt about india-rubber.

Make the class enumerate these.

It is **flexible, tough, inflammable, insoluble in water,** but **soluble in turpentine or naphtha**; it is **waterproof** and **elastic**; and it **loses its elasticity when cold.**

II. USES

1. *Make the class tell of its use in removing black-lead pencil marks from paper by rubbing.*

It is this use which gives it its name—india-rubber.

2. *Show a piece of white gas-tubing, ink-eraser, or a ball.*

This is commonly called **vulcanized rubber,** and is made by mixing sulphur with the heated india-rubber. Where it has been so treated, the india-rubber becomes more elastic, and will not afterwards soften with the heat of boiling water nor lose its elasticity through cold.

Enumerate some of the articles made of this vulcanized rubber.

3. *Show a piece of elastic band.*

Pull it and show its elasticity. Draw out one or two of the india-rubber threads and pass them round the class for inspection.

Show a piece of the cotton, woollen, or silk fabric from which all the threads have been drawn.

Is it elastic? No.

Let us see how this elastic cloth is made.

What did we say happens when india-rubber is stretched and then suddenly cooled? It loses its elasticity.

It is this fact which enables us to make "**elastic.**" The india-rubber threads are stretched to seven or eight times their length, and then wound on rollers.

In this state they are kept in a very cold room for some days. When they are taken off the roller their elasticity is gone. They do not spring back and become shorter and thicker.

While they are in this condition, they are woven up with the threads of wool, cotton, or silk into bands. But even now they are not elastic.

The bands are then passed over a hot roller, and immediately they become elastic.

4. Look at my waterproof coat. I wear it to keep me dry in wet weather, for the rain will not go through it.

It is made by spreading india-rubber dissolved in naphtha between two thin kinds of cloth, silk, or other material, and then pressing the two together between heavy rollers.

LESSONS FROM ANIMALS

Lesson XXI

THE CAT

I. INTRODUCTION

INTRODUCE a little chat about pussy, the friend of the fireside, the pet of the children.

She comes to meet the children in the morning, and is pleased to see them. How does she show she is pleased? She rubs her soft fur coat up against them, and begins to purr or sing. She means to say "Good-morning; I am so glad to see you."

Does she ever get angry? Yes, and then she growls to show she is angry. How does she tell you when she wants anything? She mews.

II. Food

Pussy at home eats all sorts of scraps from the table. But what sort of food does she like best? She likes the flesh of mice and birds better than anything else.

Picture her watching patiently and still at a hole for a mouse, or stealing quietly along after a bird. She looks anything but a gentle, playful, children's pet just now.

Make the children tell of the fierce, glaring eyes, the moving tail, the body drawn up ready to spring forward. The mouse comes out—there is a sudden rush. With sure aim she leaps and catches it in her claws. Then show the gentle purring pussy of half an hour ago changed into a fierce monster, growling savagely, and taking pleasure in cruelly torturing the poor creature she has caught, and at last tearing it in pieces, and eating it up, flesh, bones, and all.

All this seems very dreadful and very cruel, but the cat does it because she was made for it and meant for it. Let us see how this is.

III. The Cat is formed to kill

1. **Her Eyes.**—When do the mice come out of their holes? At night when all is quiet. The night, then, is pussy's best hunting-time.

You and I cannot do much at night. We cannot see. But the cat's eyes are made on purpose to see with the smallest amount of light. It is wrong to say that cats can see when it is quite dark, but they can see when few other animals can.

Bring a child to the front, and call attention to the round black spot in the centre of his eye.

This spot is the **pupil** of the eye. Light enters the eye through the pupil only. Look at pussy's eye. The pupil is not round like ours. It is a long narrow slit, but as evening comes on this slit gradually becomes wider and wider. At night the pupil is a great round window, ready to take in the faintest ray of light.

It is this which makes her **able to see when it is almost dark.**

2. **Her Whiskers.**—*Call attention to the bare patch on each side of the mouth with the long stiff hairs or whiskers standing out from them.*

The ends of these hairs act as feelers and are a great help to the cat in the dark. With them **she is able to feel her way along.**

3. **Her Feet.**—*Picture the mice—very sharp, very frightened.*

What would they do if they could hear pussy's feet trampling on the floor?

But she makes no noise as she walks along. **She walks on her toes,** and not on the sole of her foot as we do.

Look at this picture of the cat's foot. The front paws have five toes, the hind feet four. Each foot is furnished with **soft smooth pads,** so that when she moves along **she makes no noise.** There are seven of these pads on the front paws, and five on the hind ones.

If you took her up when she was angry what would you see about her feet? **Her claws.**

Each toe is armed with a **strong, curved, and pointed claw.**

When she is quietly playing with you in front of the fire, she draws up her claws so that they are quite hidden in a sort of **sheath.** But when she is angry these cruel claws are stretched out to their full length.

Can you tell me what these claws are meant for? It is with them that she seizes her prey. When she springs upon the mouse, the sharp claws pierce through into its flesh and hold it fast.

4. **Her Head.**—The head is round, the muzzle short but wide, and the **lower jaw has only one movement —up and down.** It is very strong.

(*a*) **The Teeth** are pointed, but very sharp. They are made for **seizing and cutting.** There are six small sharp teeth in front; then there are four larger teeth, also very sharp and pointed, and beyond these again, on each side of each jaw, are four broad teeth, with sharp points on their crowns.

The jaw has only one movement, up and down, and **the teeth are made for cutting flesh,** not for chewing or grinding.

Show a picture or a drawing of these teeth.

(*b*) **The Tongue.**—The tongue is not smooth, but is covered with small, sharp, horny points, which stretch backwards. When pussy has a bone, watch how clean she strips the flesh from it. She does this with the sharp rasp-like points on the tongue.

Lesson XXII

THE CAT'S BIG COUSINS

I. INTRODUCTION

LEAD the children to tell all they were taught about the cat in the last lesson.

Pussy is a flesh-eater; she kills, tears to pieces, and eats other animals, not by mere chance, but because she is specially made and intended for such food. The cat, because it is brought up in the home, has lost much of its fierce, savage, cruel nature. Yet that nature all comes out when we see our household pet prowling after a bird or a mouse.

Lead the children, step by step, to describe the structure of the cat, and to show that in every point the habits and life and food of the animal follow as a natural result from its structure.

1. The head with its wide muzzle; its sharp, pointed teeth; its single up-and-down movement of the jaw—**is made to kill.**

2. The paws are furnished with sharp claws or talons **to seize the prey.**

3. The tongue even is intended to **take a share in the same work of flesh-eating.**

4. The supple body, with its loose covering, its soft, padded feet, are all intended **to assist in the work of killing.**

5. Being a night-prowler, it requires special powers for finding its prey in the darkness. **The eyes are different from those of other animals**; while even **the whiskers have a work to do.**

II. OTHER CATS

Picture to the class some cats that live wild in far-off lands. Lead them to imagine an animal many times bigger than pussy, but with the same powerful eyes for seeing at night, the same padded feet, the same sharpened claws, the same terrible teeth; in fact, the same animal exactly, but many times larger and stronger.

The fierce beasts always sleep in their dens all day long, and **at night come out to prowl through the forests in search of their prey.**

The tiger is most like the cat—indeed he is an immense cat.

Show a picture of the tiger in the jungle, and give a rough idea of his size. Call attention to his beautifully striped coat. The lion is another of these great cats.

Show a picture and call attention to the thick shaggy mane which we do not see in the tiger.

These fierce cats are so very strong that **they prey upon animals as large as the horse and cow.** Sometimes they spring upon a man and carry him off in their strong claws.

Pictures of others of the family, e.g. *the leopard, panther, and jaguar, might be shown, and if time allowed some little story of adventure might close the lesson.*

SUMMARY OF THE LESSON

1. The cat is a flesh-eater, because she is made to kill.
2. All cats are night-prowlers; therefore their eyes are made to see at night.

3. The whiskers act as feelers and help the cat to feel its way when it is very dark.

4. The cat walks on her toes, and the toes are padded with soft pads. She makes no noise when she moves along.

5. The claws are drawn up, when she walks, into sheaths between the padded toes.

6. The jaws are very strong, have one movement only, and are armed with sharp, pointed teeth for cutting through flesh.

7. The tongue is rough and covered with sharp horny points for stripping flesh from a bone.

8. The lion, tiger, leopard, and panther are all great cats. They feed on large animals such as oxen, deer, and horses, and not on little mice as pussy does.

Lesson XXIII

THE DOG

I. Introduction

Introduce by calling upon the children to tell all they can of the dog, its nature and habits.

It is one of the most sensible animals, and is so gentle and obedient that it can easily be taught. No animal is more loving and faithful to its master than the dog.

Compare the dog and the cat in disposition.

The cat seems to learn to love the house rather than the people in it; but the dog cares little what the place may be, so long as he can be near his master.

How does the dog behave though when he meets a strange cat?

II. The Build of the Dog

1. **The Body.**—The body is longer and deeper-chested than the cat's body, but like the cat's body it is covered with a very loose skin.

Let the class tell that some dogs have long shaggy hair; in others the coat is short and close.

The legs are slender but very strong. They are made for running.

Call attention to the deep, wide chest, and show that that is meant to serve the same purpose. The dog is a good runner.

2. **The Feet.**—Like the cat, he has five toes on the fore feet, and four on the hind ones. **The toes too are padded, for the dog, like the cat, walks on his toes.** Each toe has **a strong slightly-curved claw.**

Now I want you to think for a moment about the cat's feet. When pussy lies quietly on the rug in front of the fire, where are her claws? She has them drawn back in a sort of sheath.

Are they always in the sheath? No, she sends them out when she is angry.

What does she do with them when she is walking? She keeps them drawn up.

Now the dog **cannot draw his claws back** in this way, even when he walks. Although his feet are padded, the ends of the claws rub the ground at every step.

The dog, then, **has not the quiet, noiseless step of the cat,** and his claws, from constantly rubbing on the ground, **are always blunt** and **not sharp like those of the cat.**

Lead the children to think about the dog's habit of burying bones.

He makes a hole in the ground, and hides away his bones till he wants them. It is with these strong claws that he scratches and digs. They seem to be made for this purpose more than for seizing and holding.

3. **The Head.**—The dog has a more pointed head than the cat. The lower jaw is very strong and has only one movement, up and down (as in the cat).

The teeth are sharp and pointed. They are exactly like the teeth of the cat. They are made for cutting through flesh, not for chewing or grinding.

The dog, like the cat, is a flesh-eater.

The cat and the dog do not chew. They simply cut through their food with their sharp teeth, by means of the up-and-down motion of their jaw.

Let one of the children eat a piece of bread and butter, and call attention to the movement of the lower jaw as he chews it.

4. **The Tongue.**—The tongue is not at all like the cat's tongue. Tell me how we describe the cat's tongue. It is dry and rough, covered with sharp horny points.

The dog's tongue is soft, smooth, and wet. He does not use it as the cat does. He runs (particularly when it is hot weather) with his tongue hanging out of his mouth. If you watch you will see water dropping from it. I wonder what that means.

What happens to you when you run? You get very hot and covered with little drops of moisture which we call sweat or perspiration.

The dog's body never sweats or perspires, but when he gets hot all the moisture comes out through his tongue, and as this moisture dries up, the dog's body gets cool.

You will know now why, on a hot summer day, you often see a dog lying down with his tongue lolling out of his mouth.

SUMMARY OF THE LESSON

1. The dog is a faithful friend to man.
2. The dog is made for running. He hunts his prey by running them down, not by slyly prowling round, and then springing upon them.
3. He walks on padded toes like the cat.
4. His claws are blunt, and cannot be drawn back as those of the cat can.
5. The dog has hair for his covering, and not fur like that of the cat.
6. The dog's head is longer and more pointed than the cat's head. He has a sharp sense of smell.
7. The dog's teeth are exactly like those of the cat, and are made for eating flesh.

8. The dog's tongue is smooth; the cat's tongue is rough. The dog's tongue lolls out of his mouth. He perspires through his tongue.

Lesson XXIV

DOGS

I. INTRODUCTION

LEAD the children to recapitulate carefully, step by step (as was done in Lesson XXII.), the peculiarities in the structure of the animal.

Be very careful to draw a comparison between the structure of the cat and the dog.

Have the comparisons arranged, point by point, on the blackboard, as they are elicited from the class.

II. FOOD, AND HOW CAPTURED

Show a picture of a wolf. Tell its name, and point out its close relationship to the dog. It is, in fact, a very fierce and savage dog.

Lead the class to describe the plan of hunting in the cat family—the night-prowl; the stealthy creeping towards the prey; the sudden spring.

Wolves live and hunt together in great numbers, called packs. They hunt their victim by chasing it and running it down, not by stealthily creeping up to it as the cat does.

They have a very sharp sense of smell, and can scent their prey a long way off. They run with their heads close to the ground and will follow the scent for miles.

Their hearing is also very sharp, and their eyes are large and strong.

Their eyes, however, are not made (like the cat's) for seeing at night. They are not shaded by a curtain in daylight.

The fox, jackal, and wild dog are other relations of our common dog.

Show a picture of the fox, and tell how it is hunted with packs of trained dogs, called fox-hounds.

III. Kinds of Dogs

Call upon the children to name the different kinds of dogs they have seen, and so lead up to some such classification as follows :—

1. **The Hounds.**—*Show, if possible, good pictures of each of these, as the lesson proceeds. These dogs are all used in sporting. They are all swift runners, and most of them have a very keen sense of smell.*

(*a*) **The Greyhound.**—*Notice the long, slender body and legs; the long, pointed head and muzzle.*

Such an animal is meant for speed. It has wonderful running powers. It has less power of scent than many other dogs. It is used for hunting the hare (a very swift animal).

It chases its prey by sight.

(*b*) **The Stag-hound.**—This is one of the largest and strongest of the family. Instead of the fine smooth coat of the greyhound, it has a rough, shaggy covering.

It is kept for hunting the stag.

The Scotch Deer-hound is one of the largest and strongest of the family. He stands between two and three feet high at the shoulders.

Amongst the other hounds are the **Fox-hound**, used for hunting the fox; and the **Blood-hound,** a very large animal, with powerful sense of smell, used often for tracking men.

2. **The Spaniels.**—*Note the characteristics of these dogs. They are usually clothed with long hair, mostly curly or wavy. The ears are large and pendent.*

(*a*) **The Saint Bernard** is the grandest of these dogs.

Show a picture. Tell of the power of these dogs in finding people who have been lost and buried in the snow.

(*b*) **The Newfoundland Dog** is another very large and powerful spaniel. He is very fond of the water.

Tell some stories showing the usefulness of these dogs in saving people from drowning.

The pretty little **King Charles' Spaniel** is another member of the family; and so are **the Setter** and **the Pointer,** dogs used by sportsmen.

3. **Bull-dogs.**—*Show a picture of one. Note the massive build of body, head, and legs.*

The Mastiff is the noblest and most powerful of these dogs. Among the rest are the common **Bull-dog** and the **Bull-terrier.**

They are all very clever, sensible dogs, and are mostly kept as watch-dogs.

4. **The Sheep-dog.**—*Show a picture of one. Call attention to the rough shaggy coat, the sharp, pointed muzzle, and the small, erect ears.*

They are the most sensible and faithful of all the dogs.

Tell some stories to illustrate the character of these dogs.

Lesson XXV

THE SHEEP

I. INTRODUCTION

INTRODUCE by making the children tell what they can of the sheep, as one of our most useful animals—its uses alive, its uses when dead. It spends its nights and days in the open air; hence its thick woolly coat or fleece. This is the sheep's winter overcoat.

If left to itself the coat would gradually fall off in the hot summer-time, and a new fleece would grow for the next winter.

But we cut or shear it off at the beginning of the summer, because we want it.

Tell briefly the use we make of this woolly coat.

We eat the sheep's flesh, which we call mutton; we use its fat for making soap and candles; we make its skin into leather; and even its bones and hoofs are put to some use. The young sheep we call a lamb. What name do we give to it when it hangs in the butcher's shop? We still call it lamb.

II. THE SHEEP'S FOOD

The Teeth.—We have already learned that when we want to find out what sort of food an animal eats, we must examine its teeth.

Suppose we were to offer the sheep a piece of raw meat (such as we give to the cat and the dog), would it eat the meat? No.

It would not eat the meat, because its teeth are not made to cut flesh, but to **grind and chew.**

Show the sheep's head, and call attention to the broad, flat-topped teeth in both jaws.

Teeth of this kind we call **grinders.**

But grinders would be no use if the lower jaw only moved up and down, as is the case with the cat and dog. The sheep is able to move its jaw not only up and down, **but from side to side—in all directions.** The food is crushed and ground up as in a kind of mill.

The sheep feeds on grass.

Now call attention once more to the sheep's head. Notice the sharp, cutting teeth in front of the lower jaw; and point out that there are no teeth at all in front of the upper jaw.

Instead of teeth the upper jaw has **a hard, thick pad** in front. The sheep collects up a mouthful of grass with its long tongue and lips. The row of cutting teeth in the lower jaw then hold it firmly against the hard pad in the upper jaw, and with a sharp jerk of the head, the little bundle of grass is either torn or cut off and swallowed.

III. HOW IT CHEWS ITS FOOD

Picture sheep feeding in a meadow.

If we watch one carefully, we shall see that it nibbles off the grass, mouthful after mouthful, and **swallows it at once.**

When we take a mouthful of bread and butter, what are we very careful to do? We chew it well before we swallow it.

The sheep, however, does nothing of the sort. It goes on nibbling and swallowing until it has eaten all it wants, **but it never stays to chew it.** It then goes away and lies quietly down for a long time. All the time it lies like this we may see **its jaws moving** as if it were chewing something.

It is really chewing.

The grass is swallowed, without chewing, into a large bag, which we call the **paunch** or first stomach, and the sheep goes on swallowing until the paunch is full.

While the animal is lying at rest, the grass is passed from the paunch into another and smaller bag, **the second stomach.** In this bag it is rolled up into little round balls or **cuds,** and these are brought up into the mouth again, one by one, for the purpose of being properly chewed.

This is really what the sheep is doing as it lies so quietly on the ground. The broad, flat, grinding teeth act like the millstones of a mill, and crush and bruise up the grass.

After being well chewed the grass is again swallowed, but it goes into another bag now—**the third stomach**; and from this it passes into another—the fourth or **true stomach.**

This way of eating we call "**chewing the cud.**"

There are many animals which chew the cud. Besides the sheep, there are the cow, the deer, and the goat, as well as the camel, the giraffe, and other strange animals that live in other parts of the world.

They live together in large numbers, are very timid, and generally swift of foot. Their swiftness in running is their only chance of escaping from the fierce flesh-eating animals which prey upon them.

IV. The Sheep's Feet

Show a sheep's foot. Call attention to the two parts into which the foot is divided by the deep cleft down the middle. These are really two toes.

Notice how the flat inner surfaces fit closely together, as though the foot had been split into two down the middle.

We call this **a cloven foot. Cloven** means **split** in two.

Now call attention to the hard, horny covering for the toes.

We call a foot protected in this way a **hoof.**

Show the two little toes behind. The sheep walks on its two toes only, so that these little toes behind never touch the ground. All four feet are exactly the same in form and use.

Summary of the Lesson

1. The sheep has a thick coat of wool because it lives in the open air all the year round.

2. We make our clothes of the sheep's woolly coat, and we eat its flesh, which we call mutton.

3. The sheep feeds on grass.

4. Its teeth are formed for this purpose. They are flat-topped grinders, and would not be fit for cutting through flesh.

5. There are no teeth in front of the upper jaw, but a hard horny pad instead of teeth, to assist in tearing off tufts of grass.

6. The sheep has four stomachs.

7. It chews the cud.

8. The cow, deer, and goat are well-known animals, which also chew the cud. The camel and the giraffe chew the cud too, but they do not belong to this country.

9. All animals that chew the cud are timid and swift of foot.

10. The sheep's foot is cloven, or split in two parts, and covered with a hard horny case, which we call a hoof.

Lesson XXVI

THE PIG

I. INTRODUCTION

SHOW a picture of the common hog, and let the children tell its name.

We call it a hog or pig.

Who knows what Mrs. Pig is called? A sow.

And her husband? A boar.

The pig is another very useful animal; but, unlike the sheep, it is useful to us only when dead.

We eat its flesh, which we call **pork**. Pork is not good, except in the winter. But we salt it, and cure it by hanging it in the smoke of wood fires, and it will then keep for a long time.

Who knows what we call the flesh of the pig after it has been cured in this way? We call it **bacon.**

Now if you look in the provision shop windows you will see some pigs' legs that look very much like bacon. They have been smoked and cured, and the outside skin looks brown, very different from the legs of pork you can see in the butchers' shops.

Who knows what we call these smoked pigs' legs? We call them hams. They are the hind legs of the pig.

We are going to learn something about this useful animal.

II. FOOD

Lead the children to tell of the greedy, gluttonous nature of the pig; always ready to eat up anything—not at all particular what it is.

If allowed to run loose in a field, the pig will get a living by eating the grass and grubbing in the earth for roots. If he finds his way into an orchard or a potato-field, he will live on the fallen fruit or the potatoes in the ground. He has a special liking for acorns and beech-nuts in the autumn, but nothing comes amiss to him when he is hungry.

He will even eat bits of meat like the cat and the dog.

People who keep pigs always have a large tub, into which they throw all the waste from the table—pieces of meat, bones, bread, potatoes, vegetables, pot-washings, everything,—and it all goes.

Let us compare the pig with the cat, the dog, and the sheep, and see what we can find out about him, for we know now that animals live and feed in their own particular way because they are made and intended for it.

III. Build of the Pig

1. **The Head.**—*Call attention to the long, pointed head, ending in a strong and rather broad snout.*

This snout is made of hard, tough gristle, and is intended for **grubbing in the ground.** The nostrils are at the end of the snout, and the **sense of smell is very keen.**

Picture the hog roaming through the fields in search of food. He finds, by means of his keen smell, roots and other things, although they are beneath the ground, and then with his strong snout he grubs them up. This strong snout, then, is very useful to him, and fits him to live on the food he likes best.

Lead the children to imagine a pig with a head like that of the cat, the dog, or the sheep, and show that in either case he must starve, or learn to eat different food.

The wide, rounded mouth of the cat, formed to seize and tear its prey, could not grub up roots out of the earth.

The long, sharp nose of the dog and the soft, movable lips of the sheep are each fitted for the work they have to do, but that work is not rooting and grubbing in the ground.

2. **The Mouth.**—*Notice the great mouth with its large, powerful teeth in both jaws. Besides great grinding teeth, such as those of the sheep, it has four large, sharp-pointed teeth, like those of the flesh-eaters, one on each side of the head and in the upper and lower jaws.*

In the boar, that is the male animal, these four pointed teeth grow into **great curved tusks,** which stand out from the sides of his mouth.

The wild boar is one of the most terrible animals of the forest, because of his great, sharp tusks, which he can use with dreadful effect against his enemies.

The pig, then, lives upon flesh as well as vegetable food, because he has teeth for tearing flesh, as well as others for chewing and grinding.

3. **Sight and Hearing.**—The eyes are small and deeply set, and the ears rather long and upright. The eyes of the common pig seem dull and sleepy, but in the wild state, where the animals have to be on the watch for their enemies, both sight and hearing are very sharp.

Compare the cat, dog, and sheep in this respect. The eyes of the flesh-eaters are keen and powerful, to help them to catch their prey; those of the sheep, large, timid, and watchful—ready to take alarm at the least sign of danger.

4. **The Body.**—The body is round like a barrel, the neck very short, and the head in a line with the back. It has a short, thin tail, which is usually twisted into a curl. The skin is hard and thick, and covered with stiff hairs which we call **bristles.**

5. **The Legs.**—The legs are short, and the feet are cloven like those of the sheep. The foot has **four toes**: the two front ones are covered with a horny, **cloven hoof**; the hinder ones are smaller and do not touch the ground in walking.

Now what did we learn about animals with cloven hoofs? They chew the cud.

Yes; most of them do, but the pig, although he has a cloven hoof like the sheep and the cow, **does not chew the cud.** He has only **one stomach,** and he chews his food before he swallows it.

IV. USES

You told me how we use the flesh of the pig in different ways as food. But other parts of the pig are useful besides his flesh.

1. **The Skin.**—The skin is sometimes taken off, and can be tanned into a very useful kind of **leather for saddles.**

Call attention to the thick skin, as it is usually seen in the crackling on the pork, or the rind of the bacon.

2. **The Bristles.**—These are very useful in many ways. We use only those which grow on the back, as they are thick and strong.

Lead the children to think of brushes and brooms of various kinds. The long bristles are used for making sweeping-brooms; the short, stiff ones (sometimes black, sometimes white) are made into hair-brushes, clothes-brushes, tooth-brushes.

Who has seen a shoemaker sewing a shoe? What does he use instead of a needle.

Explain why he uses a bristle, how he fastens it to his waxed thread, and how he works with it.

SUMMARY OF THE LESSON

1. The pig is chiefly useful for its flesh, which we call pork, bacon, and ham.

2. It is formed to live on roots and other things which it can find by grubbing in the earth.

3. It has a long, pointed head and strong snout.

4. The pig is not so particular in his food as either the flesh-eaters or the cud-chewers. He will snap up anything.

5. He has the grinding teeth of the sheep and cow, and, in addition, four large, sharp teeth in front.

6. In the boar these four sharp teeth grow into long, powerful tusks.

7. The pig has a very sharp sense of hearing, and his sight and smell are both keen.

8. He has cloven feet like the sheep, but he does not chew the cud. He has only one stomach.

9. Besides using his flesh for food, we make leather of his skin, and his bristles are made into brushes of all sorts.

LESSONS FROM PLANTS

Lesson XXVII

PARTS OF A PLANT

I. WHAT A PLANT IS

IN one of our earlier lessons, I told you the difference between a carrot and a piece of coal and stone. Both, we said, were dug out of the ground, and yet they are not alike. The coal and the stone are **minerals.** The carrot, although it was dug out of the ground, is not a mineral.

It lives and grows in the ground. We call it a **plant** or **vegetable.**

Everything that lives and grows in the ground as the carrot does,—the green grass, the beautiful flowers, the great tall trees, are all **plants** or **vegetables.**

A plant is made up of several parts, and each part has its own work to do; but a mineral **has no such parts.**

Illustrate this by reference to a piece of some mineral. Break a stone in pieces, and show that one piece is just like another.

Now bring forward a common plant of some kind, and let the children tell some of its parts.

It may not be the flowering time for this particular plant, and it will, therefore, be easy to show the children that certain parts of the plant are always to be found, but that others appear only at certain seasons.

II. ROOT, STEM, AND LEAVES

Look at our plant and tell me what parts you can see. First of all you can see the part that comes out of the ground and rises upwards into the air. This part we call the **stem** or **stalk.**

The stems of some plants are soft and slender, but trees have hard stout stems of wood. The stem of a tree is called its **trunk.**

Some plants have only one stem, others have a great many stems.

Call upon the class to mention a few examples of each, the teacher helping where they fail.

Show a picture of a tree, and call attention to the smaller stems springing out from the main trunk.

What name do we give to these? We call them the **branches.**

What is it that make our trees look so fresh and beautiful in the spring-time? The green **leaves.**

Who has noticed the trees in the early spring when the leaves are beginning to come? What do we see first? Little pale green knobs, which grow and swell bigger and bigger, until they at last burst out into actual leaves.

Who knows what we call them? We call them **buds.**

Now we have spoken of the stem, the branches, the buds, and the leaves. Isn't there some part of the plant which we never see? Yes, the root.

Why don't we see the root? Because it is fixed and hidden away in the ground.

The root is a very important part of the plant. It spreads itself through the soil and holds the plant firmly in its place, and at the same time it has to find food for the plant to live upon.

All these parts—the root, the stem, and the leaves—are necessary to the actual life of the plant.

III. FLOWERS, FRUIT, SEEDS

Now show another plant in bloom.

What can you see in this plant that we did not find in the other? Flowers.

The flowers are not always seen on the plant, because they have nothing to do with its real life. The plant could live and grow, and be healthy and strong, without bearing any flowers. Some plants do not bear flowers at all for many years.

The work that the flowers have to do is to produce other plants, which shall live and grow after the parent plant is worn out and dead.

Let us see how they do it.

Who has seen the pretty scarlet bean growing? You know that all the summer it bears bright scarlet flowers.

Do you know what happens when these pretty flowers die off? On each little twig where a flower has been growing there is left a tiny pod.

This grows bigger and bigger day by day and becomes the **fruit** of the plant.

This then is just what happens with all plants. The flower blooms and falls off, but when it falls off it leaves the fruit behind.

When your father grows scarlet beans in his garden he waits till these pods—the fruit—are large enough, and then he picks them for the table. But if he were to leave them to grow and ripen you would in time see in each pod a number of small oval bodies inside. These are the **seeds.**

Show some round the class.

When they are quite ripe, in the autumn, your father gathers them and stores them away till the next spring. Then if he puts them in the ground, they will spring up again and make new plants for the next summer.

Now let us see what we have learnt about plants.

1. Plants consist of a great many different parts, each part having its own particular work to do.

2. The root, stem, buds, and leaves are the parts which

have to do the work of keeping the plant alive and making it grow. They are always to be found.

3. The flowers, fruit, and seeds have nothing to do with the daily life of the plant. Their business is to form other plants to live and grow when the parent plant is dead.

Lesson XXVIII

THE ROOT

BEFORE we commence the work of the new lesson I want you to think over what we have already learned about plants.

First, who can tell me the great difference between a plant and a mineral? A plant lives and grows in the ground. It has several distinct parts. Each of these parts has its own particular work to do. A mineral does not live and grow, and it has no distinct parts.

Which parts of the plant help it to live and grow? The root, stems, and leaves.

We are now going to learn something about these parts.

The root is that part of the plant which stretches downwards into the ground.

What has it to do? It does two things for the plant.

What are those two things? It has to fix the plant firmly in the ground, and so prevent it from being washed up by the rain or torn up by the winds. It has also to find food in the soil for the plant to live upon.

Show, as specimens, a root of oats, barley, or wheat, grown in a pot for the occasion, and some roots of a few simple annuals. Let the children examine them one by one.

They are all roots, and they all have to perform the important work of feeding the plant with what they find in the ground. They are not all alike.

I. FIBROUS ROOTS

Look at this one. It is a little corn plant. I have been growing it in this flower-pot ready for your lesson.

I will shake it clear of the soil that clings to it, and then you shall tell me what it looks like.

It is made of a great many strings or threads which hang down from the stem.

I want you to remember a hard word which means a string or a thread. It is **fibre.** We often call such roots as these **fibrous roots,** because they are made up of threads or fibres.

N.B.—*A good idea of such roots may be given by showing the children a common hyacinth growing* (*as we sometimes grow them*) *in a long glass filled with water. The children will be easily able to see the long white cords stretching towards the bottom of the glass.*

II. FLESHY ROOTS

Now show a carrot, turnip, parsnip, and any other root of a similar kind.

Here we have a different sort of root altogether. There are no long strings or fibres, but the root consists of a large fleshy mass. See, if I cut one of them it is very thick and solid all through.

Let us find out why there is this difference in roots.

If I were to sow some turnip seed in my garden this season, I should get some turnip plants growing up from them. These plants would grow all the season, but when the winter came on they would not die, as many other plants do.

They would live on all through the winter, and if I left them to themselves they would, during the next spring and summer, burst out into flowers, and not die until their seeds ripened.

Such plants sleep all through the winter, and wake up and begin to grow again the next spring.

But what has all this to do with the large fleshy root of the turnip? That large fleshy root contains a store of food to feed the plant after it wakes up from its winter sleep, when it cannot get any food from the soil.

This plant not only takes in enough food to keep it alive and make it grow during the summer-time, but it stores away in these thick fleshy roots enough food to live upon till the next season.

The carrot, parsnip, radish, and beet are like the turnip in this.

Now let us turn to our corn plant.

This is a plant that springs up and lives only for one season. If left to itself it would die down as soon as it was ripe. It would not live through the winter. Instead of letting the corn die down in our cornfields, what do we do? Men called reapers cut it down in the autumn.

The corn plant, then, has only to live and grow from day to day. It has no need to store away food to live upon during the second season. This is why it has a fibrous root consisting of long white strings, instead of a thick fleshy root like the turnip.

All plants that live only one season have **fibrous roots.**

III. How the Root feeds

Let one or two of the children come to the front and examine some of the roots for themselves, one taking a fleshy, another a fibrous root.

Lead them to notice the delicate white threads or hairs along the sides and at the extremities of the root. These we call the **root-hairs.**

The little hairs stretch out into the soil in all directions. They are the feeders of the plant. Every particle of food which the plant gets from the soil has to pass up those thin delicate hairs.

If our eyes were sharp enough, we should see that each of these root-hairs is made up of a closely-packed mass of little cases or **cells**, with extremely thin, **spongy** walls.

What is the chief property of sponge? It is **porous.**

What do **porous** bodies do? They **absorb** liquids. They are **absorbent.**

The thin walls of the little **root-hairs**, then, are absorbent, and will absorb liquids.

Put one of the roots which lie on the table into a glass of water to prove that roots do absorb liquids very readily. When it is removed from the glass, after a time, show that some of the water has disappeared. It has been taken up by the root-hairs.

Now lead the class to think of their old lesson on rock-salt, and what happens when water washes through the salt buried underground. The salt is dissolved in the water, and the water carries it away.

Make them tell the meaning of the words dissolve and solution.

The very same thing happens in our fields and gardens. The soil contains just what the plant requires, but the plant cannot take it up in the solid form. The rain comes, sinks into the ground, and dissolves some of the substances in the soil. Then the little root-hairs greedily absorb all they want.

Picture the plants in our fields and gardens in dry, hot weather—the ground dry and parched—plenty of food there, but the plants starving because they cannot take it as it is. Rain comes, the plants are able to feed, and they hold up their heads and look bright and fresh again.

Lesson XXIX

THE STEM

I. Introduction

THAT part of the plant which springs out of the ground from the root is the stem. The stem rises into the light and air, and bears buds, leaves, and flowers.

Trees, shrubs, and **bushes** live for many years. They have hard woody stems.

Other plants either die down to the ground or else perish altogether in the winter. These we call **herbs.** They have soft green stems.

Let the class mention some plants of this kind.

The stems of plants are not all alike.

Most plants have strong stout stems, which can stand upright or **erect.** They seem to be pushing their way upwards, so as to bring the leaves and flowers more and more into the power of the sunlight and air. No plant can be healthy without light and air.

II. TWINING STEMS

Now look at this plant which I have here. I have grown it in this pot for your lesson.

Who can tell me what it is? It is the scarlet bean.

Look at its stem. What can you tell me about it? It is thin and soft. I have kept a tall stick standing in the pot since the plant began to grow. Who knows why? It is to support the plant.

As the plant grows it twines its stem round the stick. We call the scarlet runner a **twining plant.**

Lead the class to tell that, without some such support, plants of this kind would be likely to be bruised and broken, for their stems are very delicate.

Pictures of other **twining plants,** *such as the hop, honeysuckle, and convolvulus, should be shown.*

III. CLIMBING STEMS

Who has seen a grape-vine growing? Does it grow like a rose-tree, in the middle of the garden? No, it generally grows up the side of a wall.

Show a piece of a vine-stem, and call attention to the little green curling **tendrils.**

Let the children examine them for themselves. Tell the name, and explain the purpose they serve.

The specimen branch should show some of the tendrils clinging tightly round some twig.

Plants which cling to other things for support, by means of **tendrils,** we call **climbing plants.**

A sweet-pea in a flower-pot, and a bunch of Virginia creeper, should be shown as other examples of these, as well as pictures of such plants as the passion-flower, the cucumber, melon, etc.

IV. CREEPING STEMS

A strawberry plant ought to be easily obtainable, and it will grow well in a large flower-pot. Have one ready, with one or two good runners well developed. If the runners be pegged down at the node a few days before, it will be easy to show the new rootlets striking down into the mould.

Failing the plant, a picture must be shown.

Now I want you to look at this plant. Perhaps you do not know what it is. I will tell you. It is a strawberry plant—the plant on which our delicious strawberries grow.

Show the original plant, and then let the children discover for themselves how it grows. It sends out long thin stems which run along the ground. We call them **runners.**

As soon as the runner has grown its full length, it sends down into the ground from its extremity a great many new little roots. These not only hold the runner firmly in the ground, but absorb food for the new plant that forms at that joint.

Plants of this kind we call **creeping plants.**

Show if possible the common house-leek as another example

V. UNDERGROUND STEMS

A plant of common garden-mint will be the simplest illustration of the underground stems.

Show one. Shake the earth from it, and lead the class to note for themselves the clear difference there is between these underground parts. They are not all roots.

Let the children point out the root branches.

Now look at this whitish-looking branch which runs out from the root. It is not only different from the root branches in colour and appearance, but **it has buds here and there.** We never find buds on roots, and therefore we know this white-looking cord, with buds on it, is not a root at all, but an **underground stem.**

It runs for some distance underground, and then strikes upwards towards the light and air.

Look, here is a potato. You know that it is a vegetable, but can you tell me on what part of the plant it grew? It grew underground, and when it was fit for use it had to be dug up.

Show a good picture of a growing potato plant.

This potato is not a root, although it was dug out of the ground. What does your mother call these little hollows in the potato? She calls them eyes.

They are really buds. If I were to put this potato into the ground, new stems would spring from each of these buds.

Call attention to the picture, and show how the plant grows.

It sends out underground branches in all directions, and at the ends of these branches are the new tubers. Point out too the actual roots of the plant, which can easily be distinguished from the underground stems.

Lesson XXX

STEMS

I WANT to tell you something more about the stems of plants to-day; but before I do so, I must get you to tell me all you can remember about our last lesson.

A few simple questions will soon elicit from the class all that is required, and prepare the way for what is to follow.

I. BULBS

You all know what this is. It is an onion.

What have we on the under side of it? A great many strings or fibres.

What are these? The roots of the plant.

Then the onion itself cannot be the root? No.

This round-looking ball is really the lower part of the stem swollen very big. We call it a **bulb.**

Show a picture of the growing plant. Point out the fibrous roots stretching down into the soil, and the stem rising upwards from the thick swollen bulb.

When the autumn comes, the rest of the stem dies down and leaves only the bulb. This would live on till next spring and then send out a new stem, which would bear flowers and die after ripening its seeds.

The bulb is thick and fleshy, because in it is stored up food to keep the plant alive during the winter.

The lily, the leek, and hyacinth may be shown as further examples of these **bulbous stems.**

How do we know these bulbs are stems and not roots? I will cut the onion open and we shall soon see.

Look at this little bud right in the centre of the bulb.

Roots never have buds. The bulb is really a bud covered with layer after layer of scales or leaves.

Strip off the scale-leaves one by one till the central bud is left.

II. WOODY STEMS

Show a piece of the stem of an oak-tree side by side with a thick piece of cane. Explain that both are portions of the stems of plants.

The cane is part of a plant that grows in hot countries a long way off. It does not grow here.

Set a boy to cut it with his knife. He finds it very hard to cut. It is very hard to get the knife into the smooth outside part. Explain that the hardest part of these plants is always on the outside.

Every year new wood is formed inside the stem, and this new wood presses the older wood towards the outside. The new wood in the inside of the cane is much softer than the older wood on the outside.

Now let the boy try to dig the point of his knife into the piece of oak-stem.

Which part of this does he find hardest? The central part. That on the outside (*i.e.* just under the rough outer covering, which we call the **bark**) is soft compared with the hard wood in the middle.

All our great trees are like this.

The oldest and hardest wood is in the centre, and each year a layer of new wood is made and forms a ring all round this central part.

Show the piece of oak, and point out the rings. Tell that each ring is one year's growth, so that by counting the rings in these stems, we can learn the age of the tree.

III. The Use of the Stem

Show a piece of the branch of some tree—a willow is perhaps best for this purpose. Strip off the bark, and call attention to the thick, sticky liquid which lies beneath.

Who knows what we call this liquid? It is called **sap.**

It consists of the dissolved earth-food, which was absorbed by the spongy ends of the little root-hairs down in the ground. The work of the stem is to carry this **sap,** or **earth-food,** upwards from the root to the leaves.

It would not be of any use to the plant unless it passed through the leaves.

This sap which we see between the bark and the wood has been through the leaves, and is now fit for the plant to use.

The plant was using it when this branch was cut. It was changing it into woody matter, and next year there would have been a new layer of wood all round the outside of this, and just under the bark.

Lesson XXXI

LEAVES

I. The Nature of a Leaf

Hand a few of the simple leaves, e.g. *a lime, cucumber, mallow, and vine-leaf, round the class for inspection.*

Tell that each of these leaves consists of two parts.

Who can point out the two parts? There is first of all the thin flat broad part. This we call the **blade.** Then there is the long **stalk** which joins the blade to the twig or branch. This we call the **foot-stalk.**

The blade is of course the most important part of the leaf. It is this part which we have in our minds when we speak of a leaf.

Now I want to see which of you are in the habit of noticing things for yourselves.

Who can tell me how the leaves are placed on most plants and trees? As a rule they spread themselves as far as they can in a horizontal position, so that there is an upper and an under side to the blade.

See that the term "horizontal" is understood.

Let the children examine some of the leaves on the table, and lead them to find out points of difference in the two surfaces.

The upper surface is smoother than the under; in fact, in some leaves it is very smooth and glossy.

Now let us have a good look at the under surface of one of these leaves. Suppose we take this large mallow leaf. You will be able to see the parts as I point them out.

Let the following facts be deduced one by one from the class. The blade is very large and broad, and it is very brittle, it would easily break.

Now look at these thick stout supports that run from the stalk to the edge of the blade. There are seven of them altogether. They make a strong framework to support the blade, just as the framework of my umbrella makes a support for the silk covering.

Do you know what we call the framework of the umbrella? The ribs.

Yes; and we also call this framework of the leaf, its **ribs.**

The ribs support and strengthen the blade and keep it well stretched out to the light and air.

Pass specimens of other leaves round the class, and let the children examine them for themselves.

II. THE VEINS OF LEAVES

Now hold up the leaves to the light and see if you can find out anything more.

What do you see? A great many other lines smaller and finer than the ribs. They run all over the blade and branch out in all directions. They form quite a network in the blade.

Yes, these are really very fine branches of the thick ribs. We call them **veins.** They spread through the leaf, and as they spread, they send off smaller and smaller branches.

I want you to examine all these leaves, and you will see that in every one the veins spread themselves through the blade in all directions and make a sort of network.

Let the class examine any common leaves, e.g. *vine, cabbage, lime, cucumber, lettuce, mallow, geranium, or any other easily obtainable.*

We have a special name for all leaves of this kind. We call them **net-veined leaves.** They are the commonest of all leaves. The trees in our woods and forests, and the fruit-trees in our orchards, have net-veined leaves, and so have most of the plants in the garden.

Show the leaf of the common flag.

Now look at this leaf. It is very different from any of the others. Notice that the blade rises direct from the stem without any foot-stalk, and that it is a long, narrow, pointed leaf.

Direct the children to look for the veins, holding the leaf up to the light as before.

Can you see a network running through this as you did through the other leaves? No. There is no network.

Are there any veins at all in this leaf? There are veins, but they run side by side in straight parallel lines from one end of the leaf to the other.

Leaves of this kind we call **parallel-veined leaves.**

Make sure, of course, that the term "parallel" is clearly understood. The drawing lessons, however, should have taught this.

We have very few plants with these parallel-veined leaves in our country. The commonest are the corn plants (wheat, barley, oats, rye), the tulip, onion, lily, and hyacinth, and the rushes that grow by the banks of rivers.

Those plants whose stems are like the piece of cane I showed you in the last lesson, and which grow in hot countries, have parallel-veined leaves.

III. THE USE OF THE LEAVES

I have yet to tell you the most wonderful thing of all about leaves. The surfaces of leaves are crowded with tiny **holes or pores.** There are more of them on the under than on the upper surface.

Look at this lime leaf. Our eyes are not sharp enough to see the pores, but they are crowded together, hundreds upon hundreds in every part of the leaf.

Think how very small and how close together they must be.

These holes or pores are called **breathing pores,** for the plant breathes or takes in air through every one of them.

Now let us go back a bit.

What is the particular work which the root does? It sucks up dissolved earth-food from the soil. We call it **sap.**

What becomes of this sap? The stem and the branches carry it upwards to the leaves. It passes along the footstalk and along the veins all through the blade. The leaves then breathe in air through their breathing pores, and the plant takes from the air what it wants to make the sap fit for its food. The rest of the air which is not wanted is sent out again through the pores.

Lesson XXXII

LEAVES

I. Simple and Compound

Show a few common leaves, such as the apple, pear, plum, cherry, rhubarb, lime, oak, vine, and tell their names.

Who can tell me one point in which these leaves are all alike? They are all made in one piece; that is, they have a single blade.

Leaves of this kind are called **simple leaves.**

Now show some others, such as the scarlet bean, clover, strawberry, rose, horse-chestnut, Virginia creeper.

How are these different from the simple leaves? They are made up of several parts.

Let us see. Take the scarlet bean.

Show that the leaf is really in three parts; that there are three distinct blades, each blade having its own particular foot-stalk, which joins it to the main foot-stalk.

The three blades are not three separate leaves, but three parts of one leaf.

We call it a **compound leaf,** and the three parts are not leaves but **leaflets.**

Who knows what leaflet means? A little leaf.

Now take the clover and strawberry leaf, and show that the arrangement in these two is very like that of the scarlet bean except that the leaflets have very short foot-stalks.

The rose and the Virginia creeper will supply specimens of compound leaves with five distinct leaflets.

The two should be brought together and compared as to the arrangement of their leaflets on the main foot-stalk.

II. The Surface of Leaves

Bring together for the sake of comparison a cucumber or a vegetable marrow leaf and a cabbage leaf, a scarlet-runner leaf, *and an oak leaf. Let the children feel the surface of each, and then explain what difference they have observed.*

They will tell that the cucumber, the marrow, and the scarlet-runner leaves are **rough to the touch,** *while the cabbage leaf and the oak leaf are* **smooth.**

Tell that the roughness of the first three leaves is due to the short, stiff hairs with which they are covered.

Now let the class compare the upper and under sides of these and any other leaves ready to hand, as to colour.

Lead them to notice that, as a general rule, the upper surface of a leaf is of a darker colour than the under.

Call attention also to the fact that all these leaves differ from one another in colour.

All leaves are not the same shade of green. Some are not green at all.

III. THE EDGES OF LEAVES

Next show the lime, the rose, and the strawberry leaves, and call attention to their edges. Let the children feel them, and compare them with a few of the smooth-edged leaves on the table.

Some leaves have smooth edges, others are notched like the edges of a saw.

IV. THE SHAPE OF LEAVES

Compare now the various specimens of leaves on the table, as to size and shape. Lead the class to see that leaves vary much in these two respects.

We have all sorts of shapes—round, oval, heart-shaped, oblong, kidney-shaped, arrow-shaped, and irregular like the oak leaf.

V. EVERGREENS

Introduce these by showing a few leaves of ivy, holly, or laurel. Tell their names. Note their smooth, glossy surface and dark green colour.

What do we notice about our trees as the autumn comes on? They begin to lose their leaves.

What do they look like by Christmas-time? They are quite bare, all their leaves have fallen.

Are there any trees at Christmas-time that do not look bare? Ivy, holly, box, myrtle, and laurel.

What do we call these? We call them **evergreens.**

Explain that these plants are always green, because the old leaves do not die off until the new ones are quite formed. In this way these trees are never bare like other trees.

Lesson XXXIII

FLOWERS

Introduce the new lesson by calling attention to the fields in spring-time—bright and gay with daisies and buttercups, primroses, cowslips, and violets; and to the gardens all through the spring and summer, one mass of brilliant colours.

We like to look on the pretty flowers, because of their beauty, but besides pleasing our eyes, they have a most important work to do.

Who can tell me what it is? They have to form the fruit and the seeds.

Who has seen an apple-tree in the early spring covered with beautiful blossoms? These blossoms on the tree are its flowers. We like to see plenty of flowers on the tree, because the flowers will one day die off and leave the fruit behind.

I. The Flower-Leaves

Hand a few common, simple flowers round the class for examination by the children. Call upon one to examine his flower, and tell what he can of its appearance.

His eyes will tell him that it consists of a certain **number of leaves,** not coarse and green, like the true leaves of the plant, but **very delicate** and **rich in colour.**

Comparing his flower with others in the class, he may tell that **there is a great variety in the colour of flowers.**

By handling his flower-leaves, he will learn something of their extremely **soft, smooth, and delicate nature.**

Show, by comparing the flowers in the hands of the children, that these flower-leaves are very curiously arranged.

All flowers have not the same number of flower-leaves. Sometimes the flower-leaves are **separate from each other.** Sometimes they are **joined together at their edges,** so as to make a sort of flower-cup, or tube, or bell.

Now let the children strip off the flower-leaves carefully from the flowers.

Tell them that, beautiful as these flower-leaves are, they are not the most important part of the flowers.

II. PISTIL AND STAMENS

The most important parts of the flower are seen after the flower-leaves have been stripped off. It is because these are so important that we find them placed in the very centre of the flower, with the flower-leaves all round to protect them.

Illustrate this stage of the lesson by means of a lily, if possible, as its parts are large and can be easily seen by the class.

Now let us see what we have inside. First of all look at these long slender stalks, which stand upright from the bottom of the cup. There are six of them, and they stand in a circle round another and somewhat stouter stalk. Look at the top of each of the first six, and you will see that there is a long yellow-looking knob.

Call upon one of the class to come and pick off one of these little knobs. When he has done so, ask him to look at his fingers, and tell what he sees there. He sees some fine yellow dust.

These little knobs are really little oblong boxes filled with this yellow dust.

The stalks with their little boxes full of yellow dust we call the **stamens** of the flower, the yellow dust we call **pollen.**

Let now all the stamens be stripped off, so as to leave the central stalk the only remaining part of the flower. Call upon the class to examine it closely.

Note the upper rounded knob, and the lower swollen part where it joins the flower-stalk.

We call this central part of the flower the **pistil.**

Look at its lower swollen part while I cut it open. It is not a mere solid stalk; it is really a wonderful little box or case filled with tiny seeds.

Pick out some of the tiny seeds with the point of a penknife and let the class see them. Note how wonderfully they are packed in the little box.

This box and its seeds grow bigger and bigger, while the rest of the flower, the beautiful outer leaves, the stamens, and the upper part of the pistil, die and fall off.

STANDARD II.

STANDARD II

Lesson I

POROUS BODIES

In our last year's course we introduced the subject of porosity. It would be advisable, therefore, now that we are about to deal with the same subject in a wider scope, to re-awaken the interest of the class by the following experiment:—

Stand a piece of **cane,** *about six or eight inches long, in a* **tumbler** *half filled with* **spirits of turpentine,** *and after a few minutes apply a match to the top of the cane, when it will be seen to burst into a flame. The same may be done with* **paraffin,** *but it requires care. Now lead the class to tell all about the flame.*

Who can tell me what it is that caught light so quickly? It is not the cane; for, see, if I apply a match to this piece, it is not at all in a hurry to take fire, it does not burst out into a smoky flame as the first one did. It is the turpentine that is burning.

But the turpentine stands only about half way up the glass. How did it get to the top of the cane?

Let us try to do the same with this glass rod, or this stick of pencil. We might try for a very long time with these, but we should never get a flame from the top of them.

Take the cane out of the tumbler and ask the children to examine it, and see if they can discover how the turpentine ran *up to the top. They will at once see the little holes in the cane. But there are none in the glass rod or the stick of pencil.*

Now who can remember what we say about bodies that are full of holes? They are **porous bodies.**

We are now going to learn something more about these porous bodies; but first of all I must see what you remember about our former lessons. Can you tell me of any porous substance? Sponge, bread, sugar, chalk, dry clay, charcoal, coke, pumice-stone. How do all these things act when I place them in a saucer of water?

They take up the water into their little **pores.**

What name do we give them because of this? We call them **absorbents.** They **absorb** or suck up liquids. The cane, then, is a porous body, and this is why the turpentine ran up through its pores till it reached the top and caught fire there.

Now show an ordinary **paraffin lamp** *and a* **candle.** *Describe and pass round the class a piece of the* **wick** *of each.*

Is this wick **porous?** Let us see. I will dip it into this basin of water. Now I take it out and squeeze it. What happens? The water runs out. Then you see that the wick is **porous,** and that it **absorbs** liquids. It took up some of the water in the basin.

Now light the lamp and the candle, and try to find out how they burn.

Let us start with the lamp. The wick is a porous substance; the greater part of it lies in the liquid paraffin. The liquid rises through the pores of the wick and burns at the top, just as we saw the turpentine burn at the top of the cane.

But how can this happen with the candle, for the candle is made, not of liquid oil, but of solid tallow? See, since I lighted the wick just now, it has burnt and given out just enough heat to melt the tallow; that is, **to change it from the solid to the liquid state.**

Look at the little circle of liquid tallow all round the wick. This liquid, like all others, is quickly absorbed by the porous wick, and runs up to the top, where it is burnt.

The readily absorbent nature of the wick may be shown by the following experiment:—Take a **piece of wick,** *such as is used in benzoline lamps, and after soaking it in water, dip one end in a tumbler of water, and let the other end hang down on the outside. Almost at once the boys will see the water drip, drip from the lower end of the wick, and if an empty vessel were now placed underneath, it would, after a time, become filled with the water from the tumbler.*

How does this come about? The water from the tumbler rises through the pores of the wick till it reaches the top, and then runs down through the pores in the same way, and drops into the vessel below. It rises through the pores just as water rises through the sponge, piece of sugar, chalk, and bread. All these substances are absorbents.

Now drop some water on the table, and show how to take it up with a little roll of **blotting-paper.** *Let the boys observe that you merely dip one end of the roll into the water, and at once the liquid begins to run up through the pores until the whole of the blotting-paper is quite wet.*

We don't use blotting-paper to take up water, however.

What do we use it for in school?

Drop a blot of ink on a sheet of writing-paper, and show how rapidly the blotting-paper absorbs it. Try to do it with a piece of some other paper, and show the result.

Why does the blotting-paper absorb liquids while other paper will not do so? Blotting-paper is very porous.

So was the writing-paper at first, but in order to make it smooth and fit to write upon, it was dipped in size, and when the size dried, it filled up the pores, so that the paper is no longer porous and does not absorb.

Show a piece of **flannel.** *Dip it in some water, and let the boys see that it is very porous and absorbent. It takes up and holds water. This is why we find a house flannel so useful for cleaning and washing up.*

Lesson II

SPONGE

I. Properties and Uses

Our lessons have taught us a great many things about the sponge, and to-day I want to tell you something more about this useful substance. But before I do so, I think it is only fair that you should tell me what you remember about its properties and uses.

What is the first thing you remember about it? It is **porous** or full of holes. When it is put into water it will suck up or **absorb** the water into its pores and hold it. It is **absorbent.**

How can we get the water out again? By squeezing the sponge. We are able to squeeze it because it is a **soft** body.

What happens when we let it go after squeezing? It springs back to its former size and shape, because it is very **elastic.**

If you try to tear a sponge, do you find that it tears easily? It is not easy to tear, as it is **tough.**

Now lead the class to see that it is the combination of all these properties that makes the sponge such a useful substance for all kinds of washing and cleansing purposes.

1. It is **porous** and **absorbs** water; and as the water fills the pores, the sponge swells to a larger size.
2. It can be **squeezed** so close together that all the water may be pressed out again.
3. Its **elasticity** causes it to spring back again to its former size when the pressure is removed, so as to enable it to absorb more water.
4. It is **soft** and **smooth,** so that it will not rub or hurt even the tender skin of a little baby. It is the best thing to use for bathing a sore place (a cut or burn).

5. It is so **tough** that it will stand much using without wearing away or tearing to pieces.

II. WHAT THE SPONGE IS

Many of the objects we have had before us for illustration are things which have been made from other substances. The sponge is not made by man. It is the remains of a very wonderful animal that once lived at the bottom of the sea.

It is really only the **skeleton** of the animal, for all the rest has disappeared. In its living state the sponge was fixed by a sort of root to the rocks at the bottom of the sea, and could not move about. This skeleton, as we now see it, was then covered with a thin coating of **soft jelly-like flesh,** which also lined all the pores and tubes.

When it was taken out of the sea all this thin watery jelly drained away, and nothing was left but the tough, elastic, porous framework.

This framework is so arranged as to form a very large number of small tubes, which open on the outer surface of the sponge. These small tubes are connected in the inside of the sponge with a number of larger ones, which also open all over its surface, but with wide mouths.

In its living state at the bottom of the sea, the sponge from its own elastic nature has the power of constantly throwing out from these larger tubes strong currents of water. These currents are again drawn in by the little pores, and as they suck in the water they take in with it the food which is required for the support of the creature.

So curious a creature is this sponge that for a long time the cleverest men could not make up their minds as to whether it was a plant or an animal, but we know now that it is really an animal, although you are too young to understand the reasons why we say so. There are several **kinds of sponges.** In some the fibrous skeleton, instead of being leathery and elastic, is composed of tiny spikes of glassy flint. Why are these of little use?

III. HOW THE SPONGE IS OBTAINED

In those parts of the world where sponges are found, men called **divers** bring them up from the bottom of the sea, where they live and grow. These men are trained to dive from their childhood, and become very quick and clever.

Show a picture of the sponge-diver at work. Draw attention to the boat—the long rope leading down to the bottom of the water—the diver ready to descend with a large heavy stone attached to his foot.

Why does he want the stone? He cannot remain under water longer than two or three minutes at the outside. The stone causes him to sink very rapidly to the bottom.

In some places the diver wears a special kind of dress, which enables him to stay and breathe under water for a long time.

A few words of explanation of the diver's dress may be given at teacher's discretion.

Some rougher and coarser kinds of sponge are obtained by dragging, at the end of ropes, sharp, heavy hooks along the bottom of the sea where the sponges are found. Why would this not do for the more delicate and valuable sponges?

Lesson III

FILTERS

I. INTRODUCTION

LEAD the children to think of mother making the coffee for breakfast. She sometimes uses what she calls a **strainer.** *It is a sort of bag made of fine muslin. Show one.*

Who can tell me something about the muslin? It is **porous,** *i.e.* full of little holes.

Do you know why she uses it? She pours the coffee through the muslin, because she knows that the holes in it are only large enough to let the clear liquid run through, and that the thick coffee-grounds will be kept back in the bag.

Here I have a **flannel bag.** *(A bag with two or three thicknesses of fine flannel will be best.) Notice what happens when I pour this muddy water into it. The flannel is* **porous,** *but the pores are not large enough to let the particles of mud pass through with the water. They are kept back, and the water as it trickles through is much clearer than when I poured it into the bag.*

By pouring this water into another bag made of some material with still smaller pores, it would be easy to make it trickle through quite clear. It would be well to set such a bag aside and let it filter while the lesson goes on.

Now we have another name besides **strainer** for these porous bags. We sometimes call them **filters,** and we say that the liquid is **filtered** or **strained** through their pores.

II. A VERY SIMPLE FILTER

I have here a very simple filter, made of several folds of blotting-paper. Blotting-paper is, you know, very porous. You can easily make one for yourselves at home.

Show how it is made. Two or three circular pieces of blotting-paper are folded twice at right angles across the centre, and then opened out so as to form a sort of conical basin, capable of standing in an ordinary funnel or a tumbler.

Now here is some powdered chalk, which I will pour into this glass of water. Stir it up well. It has a white, milky appearance. See what happens when I pour the mixture into the filter. Slowly, drop by drop, the water trickles through the pores of the blotting-paper, but it is clear water now. The particles of chalk are left behind in the filter. Why is this? The pores of blotting-paper are so small that the little particles of chalk cannot pass through.

The same thing may be shown with a mixture of flour and *water. The water will trickle through clear, but the little particles of flour will be left behind in the filter.*

Refer now to lesson on "Sugar" in last year's course. Make the class tell what they remember of the process of refining.

When the raw sugar was dissolved, it disappeared in the water, and the water would have remained as clear as before, but for the solid impurities in it. These would not dissolve. It was to get rid of these solid impurities that the solution was poured into woollen bags and made to trickle through. As it did so, all the impurities were left behind in the bags and only the clear liquid filtered out into the vessels below.

III. THE EARTH A GREAT FILTER

Call attention to the rain. A heavy shower falls, and the water stands in dirty, muddy puddles. What becomes of it at last? It sinks down into the earth. Why? Because the earth is **porous.**

Have it clearly understood that in speaking of the earth we mean not only the surface soil, but the sand, gravel, and rocks of which the interior of the earth is composed. These are all more or less porous, with the exception of clay.

Make the boys tell the nature of a spring and how the layers of clay affect it. This they should be easily able to do from their geography lessons.

Now who has ever seen the water bubbling up out of the ground as a spring? Was it the same sort of dirty, muddy water which we have seen standing in a puddle after a shower of rain? No, it was very clear and bright. It became clear by trickling through the gravel, sand, and rocks underground. In this way the earth acted as a **filter** in holding back **impurities,** while it allowed only the clear water to pass through its pores.

We in great towns cannot all get fresh, clear, spring water for our use. Most of the water supplied to us is brought to our houses in underground pipes, and is kept in our **cisterns** till we want it.

The water may be well filtered at the water-works—and often is; but after it reaches our houses it is sometimes kept in **dirty, dusty cisterns**, and becomes dirty also.

Such water is not fit to drink. Many thousands of people are made ill every year by drinking bad water. It is an easy and simple matter to filter this bad water, and so make it clean and good and wholesome.

IV. HOW TO MAKE A CHEAP FILTER

Take an ordinary **flower-pot,** *which should be quite clean and new. Plug up the hole in the bottom with a* **piece of sponge.** *The sponge is porous, and a little clear water may be poured into the flower-pot to show how it trickles through. The sponge, however, would not be able of itself to cleanse bad water. Why not? The pores are too large to keep back particles of solid impurities. They would pass through easily.*

Show a piece of **charcoal.** *Put it into a saucer of water and let the children see that it absorbs the water, and is therefore porous.*

Here we have some powdered charcoal. Put a layer of this powdered charcoal, about 1½ in. thick, on the sponge at the bottom of the flower-pot, and then cover this with a similar layer of fine sand. Sand, as we have seen, is very porous, and water will trickle readily through it. We may if we wish repeat the layers or make them thicker; but we have really our filter made and fit for use now.

Show how it acts by pouring some dirty, muddy water into the flower-pot and leaving it to trickle through the hole into a glass vessel placed beneath. The water which is collected in glass will be clear and bright.

Lesson IV

SOLUBLE SUBSTANCES

I. INTRODUCTION

In our last year's course I showed you some little experiments with salt, sugar, lime, and other substances.

Who remembers what happens when I put them into water? They **dissolve.**

What does the word "dissolve" mean? It means to loosen, break up, or separate.

Then what do we mean when we say that the salt and the sugar dissolve in water? They break up and separate into such very small particles that we cannot see them in the water.

Would it be right to say that they melt? No; because when a substance melts, it simply changes from solid to liquid form. We can melt solid wax, but when it is melted we can see the liquid as it flows about in spoon.

What name do we give to all substances which dissolve? **Soluble substances.**

What do we call the water which dissolves them? A **solvent.**

What does the water with the dissolved substance form? A **solution.**

II. DISSOLVED SUBSTANCES ARE INVISIBLE

I have here in this bottle a solution of salt. You cannot see the salt in it; the water looks quite clear.

But you could easily find out that there is salt in it. How? By tasting.

Now I am going to find out the salt in another way. See, I will pour some of the salt solution into a glass. Now I have in this little bottle a liquid. (You need not trouble to know what it is.) This will soon find out the salt if there is any in the solution.

Pour two or three drops of the liquid **(nitrate of silver)** *into the glass.*

Show that the water at once becomes filled with white, curdy, solid flakes.

If we pour some of the same liquid into a glass of pure water, none of these flakes will be formed. See, the water is as clear as ever. The flakes do not come from the liquid in the bottle.

But watch what happens when I sprinkle some salt in it. White flakes begin to form at once as before.

So then, these experiments prove that substances dissolved in water disappear and cannot be seen. They are there, although we cannot see them. The liquid we poured into the solution of salt showed us that the salt was present in the water, although the water seemed to be quite clear. Now let us make the salt disappear again. A few drops of the liquid in this bottle (ammonia solution) will do it.

Pour in a few drops, and show that the solution becomes quite clear again.

The white flakes disappear; we cannot see the salt, but it is there still.

Put a spoonful of powdered chalk or some raw starch into a glass of cold water. Stir it well, and show that with all our trying we cannot make the water clear now. It is thick and milky-looking. This is owing to the solid particles of chalk or starch floating in it.

If we leave the vessel to stand for a time, all the wet solid matter will sink to the bottom and the clear water may be poured off. But that water will not contain either chalk or starch.

These substances are **insoluble** in water. The water therefore is not a **solution.**

III. WATER DISSOLVES ONLY A FIXED QUANTITY OF SOLID MATTER

I want you to watch carefully what I do next. I will fill this tumbler to the top with water; and I am going to put salt into the water, a spoonful at a time, to see how much I can put in.

Let a boy come to the front and keep the water well stirred. Call attention to the fact that, as spoonful after spoonful is added, it gradually disappears and becomes invisible.

Why does it become invisible? Because it is being dissolved in the water.

What would have happened if I had put a few spoonfuls of water into the tumbler? The water would have flowed over the top.

Explain that there is no overflow now, because the dissolved particles of the salt are absorbed into the pores of the water—for the water itself is very porous.

After about **seven spoonfuls** *have been put in, show that the water refuses to dissolve any more.*

How do we know this? Because we can see the solid particles of salt in the water.

Show that if we leave off stirring, the solid particles of wet salt can be seen to sink to the bottom of the glass.

All the rest of the salt is dissolved, it has disappeared, so that we cannot see it, but the water will not dissolve any more.

IV. SOME SUBSTANCES MORE SOLUBLE THAN OTHERS

Our tumbler of water dissolved about seven spoonfuls of salt. Now let us take another glass of water, and instead of salt we will put in lime, stirring the water well as before.

Show that in this case the lime begins to settle from the very first, and that by the time we have put seven spoonfuls into the water there is a great heap at the bottom of the glass.

Why is this? Because the water will not dissolve as much lime as salt. In fact, it dissolves a very small quantity of lime.

From the heap of solid matter at the bottom of the glass, we might imagine the lime to be insoluble in water. This is not the case.

I will prove to you that the water has dissolved some of the lime, although not much.

I will pour off some of the water, and then, to make sure there are no solid particles of lime in it, I will let it trickle through a blotting-paper filter.

You can all tell why I do this. The pores of the blotting-paper are too small to let any particles of solid matter pass; only the clear water will filter through them.

Now I am going to breathe through this glass tube into the filtered water.

Tell me what you see. If there is any lime in the water, you will see it turn white and milky-looking.

Show that it is.

So then water dissolves a large quantity of salt, but a very small amount of lime.

In the same way we should find, by testing with **sugar, alum, soda, gum,** that water dissolves different quantities of these different substances.

V. SOLUTIONS OF HOT AND COLD WATER

Put a piece of lump-sugar into a glass of cold water, and another into one of hot water. Show that the hot water dissolves the sugar much more rapidly than the cold. And so it would alum, soda, or gum.

Try the same with two pieces of salt. The salt dissolves as easily in cold as in hot water.

If we were to try the same thing with two pieces of lime, we should find that cold water dissolves this substance better than hot.

Lesson V

SOLUBLE AND INSOLUBLE

INTRODUCE the new lesson by leading the children to tell all they can of the nature of soluble substances—the distinction between "melting" and "dissolving" a substance—the meaning of the terms "solvent" and "solution."

We have hitherto used only water to dissolve other substances, and those things which will not dissolve in water we have spoken of as **insoluble** substances. But we are now going a step farther. We shall see as we proceed that water is not the only solvent.

I. Soda

Show a greasy, oily bottle. Tell that you want this bottle cleaned for a special purpose. Fill it with water (first cold, then hot) and shake it well.

Call upon the class to explain that the water, even the hot water, will not remove the grease. Let them examine the bottle.

Why is this? The fat and oil will not dissolve in water.

Now empty the water from the bottle and supply its place with a strong solution of soda. Shake the bottle for a minute or two, and let the class examine and explain.

The grease which was insoluble in water is readily soluble in soda. The soda breaks it up into fine particles; it forms a sort of milky-looking fluid. When we pour that away, the bottle will be seen to be quite clean.

Soda is a solvent for fat and oil.

II. Spirits of Wine

Next show a piece of camphor. Tell briefly its properties and uses.

Put it in water.

If we left it for a long time in water, so little of it would dissolve that we may practically say it is insoluble in water.

But I have in this bottle a solution of camphor.

Let the children smell the bottle. It is quite clear, then, that camphor, although it is insoluble in water, has been dissolved in something else.

Alcohol or spirits of wine is a solvent for camphor.

Pour a little of the camphor solution into a glass of water and show that the solid camphor immediately reappears in the form of white, feathery flakes. Explain carefully the reason for this.

III. NAPHTHA

Show some pieces of india-rubber and gutta percha.

What happens to these substances if I put them in water. The water has no effect on them. They are insoluble in water.

But here I have a solution of india-rubber, proving that it can be dissolved, although it will not dissolve in water. I put a piece of solid india-rubber into a liquid some time ago. Now it has disappeared, because the liquid dissolved it. The liquid was **naphtha.** At the same time, I put some other pieces into water and also into spirits of wine. Let us examine them.

Take them out and let the children examine to see they are quite unchanged.

Naphtha, then, is a solvent for india-rubber and gutta percha, both of which are insoluble in water and spirits of wine. The solution made in this way is spread on woollen cloth and makes it waterproof.

IV. SOAP

Let one of the boys purposely soil his hands with grease and dirt in order that he may go through the process of washing them clean before the class.

Make the class tell what he is to do. Let him first dip his hands into the water without using any soap.

Show and explain what happens.

Then let him take the soap in his hands and rub them together in the water. As he does this, call attention to the lather which soon covers them.

Where did this come from? It is the soap which has been dissolved in the water.

But the lather on the boy's hands is very black and dirty-looking. That dirt did not come from the soap, it came from the boy's hands.

Tell that the soap (which, as we have seen, is soluble in water) forms a lather, and that the lather dissolved the grease and dirt *on the boy's hands, just as the soda dissolved the grease on the sides of the bottle.*

Now let the boy dip his dirty soapy hands into the water again, and show that the lather, with all the dirt and grease dissolved in it, at once falls off and mixes with the water. His hands are now clean, and all the dirt is in the water.

V. Soap made from Fats and Soda

Take a small bottle half full of oil and fill it up with a strong solution of soda. Stand it down, and show that at first the oil floats on the top of the solution and does not mix with it.

What effect has soda upon fats and oils? It dissolves them. Let us see.

Shake the bottle well for a minute or two. Show that the oil and soda gradually mix and form a new substance altogether different in appearance. Stand the bottle down, and when it has stood a short time, show it round the class.

Call attention to the watery-looking fluid at the bottom and the thick, newly-formed substance floating on the top of it. It is not at all like oil in appearance.

Take some of it out. Pour a drop or two into a boy's hand and let him rub it with his finger.

Does it feel greasy and oily now? No, it is soft and smooth and soapy to the touch. It is, in fact, **soap.**

All that remains is to drain off the watery part of the solution, and then change the new soft soap into the solid form. How can this be done? By boiling.

The new soap is liquid because it contains a great deal of water. If we can get rid of some of this water, we shall change the liquid into a solid.

Boiling would drive off some of the water in the form of steam, and as this went on the liquid would gradually get thicker.

This is exactly how soap is made in our great factories, only on a very large scale.

Lesson VI

ADHESIVE SUBSTANCES

I. How to stick Paper

Show one of the reading-books with some leaves loose.

What do we do when we find our books getting into this state? Stick the leaves in again. What do we use? Gum.

Call upon a boy to show how to stick the leaf in. Dip a brush in the gum and smear it over the edge of the leaf—so.

What happens when it is placed in the book? It sticks and remains there.

Try with water to stick another leaf. Why does this one not stick? Because gum is a sticky substance, water not sticky.

Let a boy dip his finger into the gum and show that some of the gum remains sticking to his finger. It sticks fast too, for he finds that it gives him some trouble to wipe it off, and he cannot get rid of it altogether except by washing his hand.

Now I want you to try and remember a hard word which means the same as our little easy word sticky. The word is **adhesive.** Adhesive substances are those that stick other things together.

Can you tell me what else I could have used to stick our leaf in the book just now? Paste would do as well.

Where have you seen men using paste to stick things together? Bill-stickers post up their bills with paste. They smear the back of the bill with paste and then place it smoothly on the wall, where it sticks fast.

Here is some paste. Call out a boy to stick up a bill.

How does the paperhanger put paper on our walls? Just as the bill-sticker puts up his bills. **Paste,** then, as well as gum is an **adhesive substance.**

Refer next to the common postage-stamp.

How do we fasten it to the envelope? We wet the back of the stamp and press it on the paper.

Explain that it would be awkward if, when we wanted to post a letter, we had to carry about a bottle of gum.

This is why the stamps are always sold with an adhesive gum spread on the back. All that is needed is to wet the gum, and it sticks.

It is just the same with envelopes and post-wrappers. We close them by wetting the adhesive substance on their edges.

Show and illustrate this.

I sometimes stick my envelopes in another way.

Here is a stick of sealing-wax. Wetting is no use in this case. We must melt the wax. See, I will put it in this flame, and as it melts let some of it fall on the envelope. If I press the two parts of the envelope together, the wax will hold them fast.

Do it, and let the children see.

Paper then may be stuck with such adhesive substances as paste, gum, sealing-wax.

II. How to stick Wood

I daresay you have seen a carpenter at work. How does he stick pieces of wood together? With glue.

Show that paste, gum, and sealing-wax would be quite useless for this purpose, and why. Here is a glue-pot.

Show a piece of solid glue. This is no use in its present state, and wetting will not do. It must be **melted.**

Put it over the fire, and while it is melting tell that it is made by boiling the hoofs and waste portions of the horns and skins of animals.

When the glue is melted, show it to the boys and then join two pieces of wood together.

Tell them that the joined pieces must stand aside for some time for the glue to harden, but that when it is hard it will hold them very fast.

III. How to stick Bricks and Stone

We will now leave the carpenter and think of the bricklayer and stone-mason. You have all, no doubt, seen the bricklayer building a wall.

What does he use to fasten his bricks together? Mortar.

Why? Because mortar is an adhesive substance, and the very sort of adhesive substance to make bricks and stone stick together.

Show that none of the other adhesive substances we have already examined would do for this.

Mortar is made of lime and sharp sand, with generally about three times as much sand as lime. When the two have been well mixed they are made into a soft paste with water. This paste we call mortar. As it dries, it becomes very hard; if good lime and sand are used, it becomes in time as hard as stone.

Cement is a sort of mortar made from special chalk and limestone mixed with clay. It is used largely to make the concrete foundations for walls, and for joining stonework where special strength is wanted. It is usually mixed with three times its amount of sharp sand.

Plaster of Paris.—*Show some and illustrate its use by joining two pieces of stone or two bricks with it.*

Mix by pouring the powder, a little at a time, into water and stirring constantly. The bricks should be dipped in water to help the plaster to adhere.

When the bricks have been joined, stand them aside for a while, and then show how firm and strong the plaster soon becomes.

Lesson VII

FUSIBLE SUBSTANCES

I. MEANING OF THE WORD "FUSIBLE"

IN one of our early lessons we held a lump of wax in an iron spoon over the fire. What happened? The wax melted. Let us do the same again now.

Call attention to the change which the wax undergoes. The solid lump first begins to get soft, then its particles seem to fall apart, and at last it becomes a liquid; it flows about in the spoon; it takes the shape of the spoon or of any vessel into which it is put. If we were to tilt the spoon, we could make the wax in it fall away in drops.

What kind of substance have we been describing? A liquid. The wax was a solid lump at first. The heat of the flame has changed the solid into a liquid. This is exactly what we mean when we say that the wax has melted.

Now I want you to remember a hard word, which means the same as our easy word **melt**. The word is **fuse**. Spell it. I will write it on the black-board. We may say we **melt** the wax or **fuse** it.

We mean that we change it from a solid to a liquid.

Because we are able to change the wax from a solid to a liquid, we say it is a **fusible substance**.

When the wax is in the liquid state, we say that it has been **fused**.

But look! what has happened while we have been talking? The **fused** wax has got cold, and is now changed back again from the liquid to the solid state.

Now let us try the same thing with this piece of chalk. Does this substance change with heat from solid to liquid? No.

Illustrate further with wood, coke, brick, slate, stone. These do not **fuse** *with heat. We call them* **infusible** *substances.*

So then we have learned:

1. That heat changes the wax from the solid to the liquid state.

2. That when this takes place the wax is **fused or melted**.

3. That we call the wax a **fusible substance**, because we can **melt** it.

4. That those things which will not **fuse** we call **infusible substances**.

II. OTHER FUSIBLE SUBSTANCES

Call upon the children to name any substances which they have seen melted. They will probably mention tallow and butter.

Show that they are right; that these are **fusible substances,** *and then lead them to think of the fusion of ice.*

What is it that fuses ice? Heat.

What becomes of the ice? It is changed into a liquid —water. Ice then is a **fusible** substance.

Put some powdered loaf-sugar in the spoon, and place it over the flame of the lamp. The sugar fuses and becomes liquid, although not so quickly as the wax.

Sugar is **fusible.**

Now show a piece of roll-sulphur. Powder it fine with a hammer, and put it into a common flask. Carefully heat the flask over the spirit-lamp, and show that **sulphur** *is a* **fusible** *substance. It quickly changes into a liquid, and may be seen to flow about at bottom of flask.*

Sulphur is **fusible.**

Next show a piece of glass tubing. Hold it in the flame of the Bunsen burner, and show that the glass becomes so soft that we are able to bend it.

Explain that our flame does not give heat enough to melt the glass into a liquid, but that if we put some pieces of glass into a vessel in a very hot furnace the glass would fuse and change into a liquid.

Glass is a **fusible substance.**

Lastly, put some lead into the iron spoon and place it over the flame. It melts or fuses and flows about in the spoon as a liquid.

Lead is **fusible.**

Certain of our minerals are useful to us entirely because they are fusible. Like lead they can all be melted or fused with heat. We call them **metals.** The commonest are iron, lead, copper, tin, zinc, silver, gold.

Elicit these from the scholars.

Now then we have learned that all the substances we have mentioned are **fusible**; but we have also seen that some fuse more easily than others. **Ice** will fuse if we hold it in our warm hands; **tallow** and **butter** before fire; **wax, sugar, sulphur** melt readily over the flame of the lamp; but **glass, lead,** and all the metals require more heat before they will change into the liquid form.

III. SOLDERS

The metals all differ from one another in their **fusibility.** Some require much more heat than others, to fuse. **Tin** is the most easily fused of metals. **Lead** is also easily fused, but **iron, copper, silver, gold** require great heat.

Some metals when in the liquid state are mixed together and then allowed to cool. They are then called **alloys.** When an alloy is made of two metals it is more easily fusible than either. That is to say, less heat melts the alloy than either of the metals of which it is made. The handle is broken off the tin teapot. The tinman mends it with an alloy of lead and tin, called **solder.** The alloy or solder melts more easily than the tin of teapot. In other words, he knows he can put the hot, melted solder on the pot without the chance of melting the tin.

N.B.—*The metals mercury, potassium, and sodium are purposely excluded here.*

Lesson VIII

SOME MORE ABOUT METALS

CALL on the children to name the metals mentioned in the last lesson. Make them tell that they are all **minerals**—*they are dug out of the earth; that they have all one common property—they are* **fusible**; *but that some melt more easily than others, tin and lead being the most fusible, iron and gold the most difficult to melt.*

Show some specimens of each, and lead the class to work out the following properties:—

I. LUSTROUS

Call attention to some object made of bright **steel.** *Explain that steel is highly prepared iron.*

Note its bright, polished surface. Rub it with a piece of wash-leather.

The more we rub, the brighter it shines. We say that it is **lustrous**—that is, full of **lustre** or **brightness.**

Treat in the same way clean polished surfaces of copper, zinc, and tin.

They too have a very bright **lustre,** although they are not all of the same colour. They shine, when rubbed with leather, more brightly than before.

Next show a piece of **lead.** *Let the children compare this with the metals they have examined.*

What difference do they find? It is not bright and lustrous, like the **steel, copper, zinc, tin.** It is dull and does not shine.

Now show a freshly-cut surface.

What can we say about this? It is bright and lustrous as the other metals were.

Explain that if we set this piece of lead aside for a time, its bright freshly-cut surface will rapidly lose all its lustre, and become dull and grey like the rest.

The **tin,** if long exposed to the air, would in time become dull and tarnished on the surface. **Copper** and **zinc** would tarnish and after a time rust on the surface. **Iron** and **steel,** with all their brilliant lustre, will not only become tarnished and dull on the surface, but actually rust, and in time rust away if left exposed to the weather.

Show a knife or some other article with a spot or two of rust on it. It was perhaps left out in the garden for a night.

Show also one with the thick red rust eating the metal away.

What do we do to prevent our iron railings from rusting away? We cover them with paint, because paint is not porous and will not allow the air to get at the iron.

Show a bright new gold or silver coin or ornament. Call attention to the same brilliant lustre on both. Explain that silver in time becomes slightly dull and tarnishes a little, but does not rust. Gold will neither tarnish nor rust.

We call gold and silver **precious** metals, because they do not rust away in the air. Iron, copper, lead, zinc, and tin we call **common** metals.

II. MALLEABLE

Show a thick piece of lead.

Let one of the boys come to the front and beat it with a hammer. After hammering, let him explain the result to the class. It has been spread out **much longer** *and much* **wider,** *but it is* **thinner,** *and it has* **not broken.**

What would have happened if he had tried to do the same with coal, coke, brick, etc.? They would have been broken into pieces, but would not have spread out as the lead did. They are all **brittle.**

Because the lead can be hammered into different shapes we say it is **malleable.**

A malleable substance means something that can be hammered without breaking. All the metals we have examined are malleable, but they cannot all be hammered out as easily as lead.

Some of them have to be **heated** and made **soft** before they can be beaten.

Beat a piece of iron as we did the lead and compare the results.

Who has seen the blacksmith at work in his forge.

What does he do? He makes the iron red hot in the furnace, and then he is able to beat it into the required shape on his anvil.

Show a piece of **sheet-iron,** *and tell that the metals are generally flattened out into* **sheets,** *not by hammering but by rolling between heavy rollers.*

Show a sheet of **gold-leaf.** *Call attention to the thinness of the sheet—thinner than the finest paper.*

Gold is the most malleable of all metals. Silver is not quite so malleable as gold, although that too can be beaten into very thin leaves.

Show one.

Copper and **tin** are also very **malleable.**

Show foils of each.

III. DUCTILE

Show some **iron, copper,** *and* **steel wire.** *Explain that these thin cords of metal have been brought into their present state by being* **drawn** *through holes in a steel plate. Take any one for example.*

This was perhaps at first a thick round bar of iron an inch or two in length. It was made soft in the fire and then passed through one of the holes in the plate. This hole being smaller than the iron bar, squeezed it as it went through, making it thinner and longer.

It was next drawn through a smaller hole, then through a still smaller one, and so on—each hole being smaller than the last.

Every time the iron was drawn through a hole it became thinner and thinner and longer and longer until it became a great length of this thin wire.

All those metals which can be drawn out into wire in this way are said to be **ductile.**

Gold is the most ductile of all metals. One ounce of gold can be drawn out into a wire which will reach 1300 miles. It is then like very fine thread.

Silver is also very ductile, and so are steel, iron, and copper.

Zinc, tin, and **lead** can be made into wire, for they are **ductile**; but we shall see why they are not of much use as wire.

IV. TENACIOUS

Show some pieces of thin wire—steel, iron, copper, and lead. Take the steel first. Fasten each end of the wire securely round a short stick, and let two boys come out and pull against each other. The class will observe that with all the pulling, the wire **holds firmly together,** *and shows no sign of breaking.*

It would stand much more force. The steel wire holds **together bravely** as more strength is exerted.

I want you to remember a hard word, which means **holding together.** It is **tenacious.**

Write it on the black-board and have it spelt.

Steel is very tenacious.

Try now with iron, copper, and lead wires. Show from this that **steel** *is the most tenacious,* **lead** *the least.*

Lead requires very little force to break it. Tin is more tenacious than lead, copper than tin, and iron than copper.

Lesson IX

IRON

I. INTRODUCTION

We are now going to learn something about each of the metals examined in the last two lessons. We will start with iron, as it is best known. Why? Because we see more things made of iron than of any other metal.

What does that show? That iron is the most useful of the metals.

It has been called the "King of metals."

We will now find out the properties of this metal, and see how it is useful in its own way.

Iron is a very curious metal. We use it in **three different states,** and the properties of all three are different. Instead, therefore, of beginning our lesson by finding out the properties of iron, we shall first of all learn something of the three different states in which iron is prepared for use.

II. IRON, A MINERAL

Iron, like all other metals, is dug out of great pits in the earth, called **mines.** The iron is **not pure,** but mixed with earth, sulphur, and other substances.

Show some specimens of iron-stone, and tell that in this state we call it **iron-ore.** *The iron is there, but we could not use it in that state.*

III. CAST IRON

1. **Roasting the ore.**—The ore, broken up into pieces about the size of one's fist, is mixed with coal and piled into great heaps. The whole mass is then set fire to and left to burn for a long time.

Put a small piece of **sulphur** *in an iron spoon and hold it over the flame of the spirit-lamp.*

What do we notice? The sulphur is very inflammable; it readily takes fire, and sends off dense fumes of smoke as it burns. The roasting of the ore is to get rid of the sulphur. That burns away, but the earthy matter as well as the iron is left behind after the roasting.

2. **Smelting.**—The roasted ore is mixed with about the same quantity of coal or coke and limestone, and is then thrown in at the top of immense furnaces, built in the form of a cone and from 50 to 70 feet high.

They are called **blast or smelting furnaces.**

Show a diagram of one of these blast or smelting furnaces. Describe its structure—its strong solid stone and brickwork; the gallery round the top, for feeding the furnace with iron-ore and fuel; the great powerful bellows for sending in blasts of air. Compare the bellows of a blacksmith's forge.

What is the object of the bellows?

Every half-hour fresh quantities of ore, fuel, and limestone are thrown in by the men at the top, and this immense furnace is regularly fed, and burns day and night for years. It is never allowed to go out or even get cool.

Draw attention again to the diagram. Show the basin-like hollow at the bottom.

What happens to iron and all the metals if they are heated? They melt.

Why? Because they are fusible.

Then, when the ore is placed in the smelting-furnace, what will happen to the metallic iron it contains? All the iron will melt. As it melts in the furnace it runs through the mass of earth, fuel, and limestone, and falls into the basin-like hollow below.

Why does it run down in this way? It is heavier than other substances in the furnace.

The clay and limestone form a new substance—**slag,** which floats on the surface of the heavier liquid iron, and from time to time flows out through a hole in the side of the furnace.

Now call attention once more to the diagram, pointing out the long iron rod at the bottom. Tell that every twelve hours men tap the furnace with this long rod, and through the hole the white-hot liquid iron flows out into **moulds of sand** *made on the the floor.*

Describe the tapping process; picture the white-hot metal with its dancing red sparks flying off in all directions, as it flows with something of the consistency of treacle. Tell of the dangers of the men.

The tapping over, the hole is plugged up again, and the liquid iron in the sand-moulds is left to cool.

Show a diagram of the sand-moulds. Tell that when the iron cools, it is turned out from the moulds in a solid block, about 3 *feet long and* 4 *inches across.*

These blocks are called **pigs of iron.** Because they were poured in the liquid state into a mould and left to cool, we say they are **cast iron.**

IV. WROUGHT IRON

Cast iron will not do for all purposes, although I cannot tell you why in this lesson. In the blast-furnace the iron, as it melted, became mixed with some of the charcoal of the coke and coal. The cast-iron pigs still have some of the charcoal in them.

They have next to be put into the **puddling-furnace**—an intensely hot furnace, where a flame is made to play over them, although they never touch the fuel which is burning.

Draw on the black-board a sketch of this furnace, showing the fuel burning in the fireplace at one end, the flue for carrying off the gases at the other, and the flames playing on the iron-pigs in the space between.

This flame melts the iron, and at the same time burns up the charcoal it contains. A man keeps the melted mass stirred with a long iron rod till it is ready to flow out into moulds.

Each mould as it cools turns out a solid mass of iron weighing about 4 cwts.

These lumps of iron are again placed in the **puddling-furnace,** but are only heated sufficiently to make them soft and plastic. They are then lifted out of the furnace whilst at a white heat, and beaten with immense hammers worked by steam-engines.

The heating and hammering are repeated again and again, and then the iron is cut up while still soft into bars. It is now ready for use, and is called **wrought iron.**

V. STEEL

Show a few common articles made of steel, and ask the children to name any more they can. All are made of iron in a very highly prepared state.

This steel may be made both from pig and wrought iron, but, in either case, it becomes so changed in its properties that it is an entirely different metal. We cannot now enter into the modes of preparing steel.

Lesson X

CAST IRON

I. PROPERTIES

SHOW one or two common articles made of cast iron. Let the children examine them.

Tell that each of these things was made by pouring the fused pig-iron into a mould, and letting it cool. When cold it was taken out of the mould in the shape we now see it.

It was **cast** or **moulded into that shape,** and we call it **cast iron.** Let us learn something of the properties of cast iron.

1. **It is heavy.**—You have handled these cast-iron articles; what can you tell me about their weight? They are heavy. Cast iron is a heavy metal, but we shall learn that it is not so heavy as some of the others.

2. **It is very hard.**—Now take this knife, and see if you can cut it. You cannot cut it or make the least scratch upon it. What, therefore, can you tell me about cast iron? It is an extremely hard metal.

3. **It is brittle.**—*Take next some inexpensive article, the breaking of which will not be a serious matter, and give it a smart tap with a hammer.*

What have we done? The blow has broken the thing.

What does this show? That it is very brittle.

Who has ever seen an iron fender broken across? That fender was made of cast iron, and it has been broken by a blow of some sort, **because it is brittle.**

Tell of the tops of iron railings often found in gardens, and how they came there; of iron saucepans falling on the stone floor from their shelf; the result, and why; of the iron standards of school-desks being found broken across, and so on.

4. **It is not malleable.**—If cast iron is brittle and breaks with a blow, it cannot possess some of the other qualities which most metals have.

What happened to the piece of lead which we hammered? Did it break? It spread out and flattened as we beat it.

What do we say of the lead because of this? It is malleable.

What does that mean? It can be hammered out.

What shall we say about the cast iron, then, which breaks into pieces when it is hammered? It is **not malleable.**

5. **It is not tenacious.**—Lead and other metals are malleable, and flatten out with hammering because their particles hold firmly together.

How do we describe this quality? We say they are tenacious.

But if a substance is brittle and falls to pieces when it is struck, it is clear that its particles do not hold together.

What shall we say about the cast iron? It is **not tenacious.**

6. **It is not ductile.**—Again, if it is not tenacious, would it be any use to try and draw the cast iron out into wire? No.

Why not? The drawing and pulling would easily snap the metal, as its particles do not hold firmly together.

What else can you tell me, then, about the cast iron? It is **not ductile.**

7. **It can bear heavy pressure.**—*Stand a thin bar of lead on end, and press downwards upon it.*

Call upon the class to note that the downward pressure soon twists the lead out of the perpendicular, and bends it.

Show that it would be impossible to do the same with a similar bar of cast iron.

Cast iron will bear almost any amount of downward pressure; it will neither twist out of shape nor break asunder. This is an important property in cast iron.

8. **It is easily fusible.**—The great and most useful property of cast iron is that it is **very easily fusible.** It melts with less heat than either wrought iron or steel, and at the moment the molten iron becomes solid again, it **expands or swells out.**

When, therefore, some of the liquid iron is poured into a mould for casting purposes, this swelling out of the metal, just as it becomes solid, presses it into every corner, and we get an exact impression of the mould.

Illustrate this process of moulding once more with wax.

Show the difference between a perfect and a faulty impression

II. USES

Lead the class to see that the various uses to which we put cast iron are dependent upon its peculiar properties.

It is easily fusible and can be moulded into any shape we wish, but it is very brittle and will easily break with a blow.

It is used for all sorts of ornamental work and for articles in which there is not much wear and tear.

Fenders, fire-grates, railings, iron bedsteads, water and gas pipes, brackets, saucepans, and kettles *may be mentioned among such articles. These will last for a long time if properly treated.*

The one thing to remember is that they are made of cast iron; that cast iron is very brittle, and will not stand a blow.

The poker is a dangerous thing for our stoves.

Cast-iron **pillars** are often used as **supports for buildings, bridges, arches, and sheds.** This is owing to the power of cast iron to bear a very great amount of weight or downward pressure.

Let the class give instances of the use of such columns or pillars in their vicinity.

Lesson XI

WROUGHT IRON

I. INTRODUCTION

LET the class recapitulate briefly, by means of a few suitable questions, what they have learned of the process of converting pig-iron into wrought iron.

See that they clearly understand that iron of every sort must at one time have passed out in the molten state from the smelting-furnace into the sand-moulds, and so formed into pigs of iron.

Make them tell of the **puddling-furnace,** *and the repeated heating and hammering of the metal, and especially of the object sought in the process. When the iron has been heated and hammered again and again sufficiently,—when it has been* **worked** *enough, we speak of it as* **wrought iron.**

Explain that **wrought** *is only another word for worked.*

Wrought iron, *therefore, means* **iron that has been worked.**

II. PROPERTIES

Show in the first place a few articles made of wrought iron, and lead the class to see that wrought iron is hard and heavy, and in this respect differs but little from cast iron.

1. **It is tough.**—*Take a bar or strip of wrought iron, and strike it with a hammer, beat it on the table or on a stone, bend it, or treat it in any other rough way.*

Now who can tell me the great difference between this piece of wrought iron and the cast iron we examined in the last lesson? Cast iron is very brittle and breaks, but wrought iron is not brittle. It is **tough.**

2. **It is flexible.**—*Bend the bar again in various directions.*

Did we try to do this with the cast iron? No.

What would have happened if we had tried? The cast iron would have snapped in two, because it is very brittle. Because it is able to bend, we say that wrought iron is flexible.

3. **It is malleable.**—*Next beat the bar with the hammer, and refer again to the lead which we beat in a similar way.*

What did we say about the lead? It is a malleable metal.

Does the iron spread and flatten out like the lead? No.

Then shall we say the wrought iron is malleable? Let us see.

The reason the iron does not flatten as the lead did, is that it is too hard. The lead, as you know, is soft.

Who has seen a blacksmith at work? He hammers his iron into any shape he wishes, but first makes it soft.

How? He puts it in the furnace and heats it.

Refer to the **poker in the fire.** *It soon becomes red hot. If the blacksmith put this bar into his furnace, it would soon become red hot, and he would be able to hammer it into any shape he might wish.*

What then shall be said about wrought iron? It is **malleable** when made red hot.

4. **Ductile.**—*Show a few lengths of iron wire of various thicknesses.*

We know that cast iron cannot be made into wire. This wire is made of wrought iron, after it has been heated and worked in the **puddling-furnace** and under the great hammers. What are we to say, then, about the wrought iron, because we find it in the form of wire? It is ductile.

Wrought iron can be made into wire less than a quarter of the thickness of the hairs of our head.

5. **It is tenacious.**—Who can tell me why wrought iron is malleable and ductile? Because its particles hold very firmly together. It is tenacious.

6. **It is not easily fusible.**—Cast iron is very fusible. It easily melts into the liquid form.

Wrought iron can be melted only in the most powerful furnaces. It is therefore in this respect again the exact opposite of cast iron. **It is scarcely fusible.**

When it is heated it first becomes red hot and then white hot, and in this state it is soft enough to be moulded into any shape by the blows of the hammer and cut or pierced with holes, as we might treat a piece of clay. It is quite **plastic** when red hot.

7. **It welds when red hot.**—Wrought iron has another very valuable property when red hot. What do you do with your iron hoops when they break? We take them to the blacksmith?

Did you ever watch while he mended one?

Lead the children in this way to describe the process of **welding**. *The process itself might be illustrated by joining two pieces of plastic clay in such a way as to hide the joint.*

III. USES

Lead the class again in this case to see that the peculiar usefulness of wrought iron is dependent upon its properties as a malleable, welding, tenacious, ductile metal.

Let them name some of the many things about the house and school made of this metal.

Take them in imagination to the blacksmith's shop, and lead them to think of the immense variety of domestic articles he is capable of turning out—all worked up into their required form with the help of the forge, hammer, and anvil.

Tell of the great girders or beams for bridges and arches and for supporting the upper floors of large buildings.

The immense strength and tenacity of this metal specially fit it for such purposes.

Wrought iron rolled into sheets is used for making boilers, and a very large part of every steam-engine is made of wrought iron.

Show a **common tin sauce-pan.** *Explain that this is not really tin. It is made of thin sheet-iron.*

Iron, however, if used for such purposes would rust. So to preserve the iron, as well as to make a nice, clean-looking metal for our pots, pans, sauce-pans, and kettles, the sheet-iron is dipped into a bath of melted tin. Some of the liquid tin adheres to the iron, and as it cools forms a white coating all over its surface.

We have already spoken of wire. Tell next of chains of every variety, large and small, made to tug and strain and to resist enormous force.

Why would not cast iron be suitable for chains?

Lesson XII

STEEL

I. CAST AND SHEAR STEEL

SHOW some articles made of steel. Lead the class to notice the **lustre** *of their bright polished surfaces.*

Steel is capable of taking a very bright polish.

Call attention to the words **cast steel** *and* **shear steel** *which appear on one or other of the articles.*

The process of steel manufacture is too intricate for the capacity of so young a class.

It will be sufficient to tell simply that the steel is prepared by being kept for weeks at a stated heat in the furnace and then allowed to cool. It is afterwards treated in different ways according to the purpose for which it is required.

Some of it is cut up into small pieces and melted in **crucibles** in an exceedingly hot furnace.

Explain the word "crucible."

The fused metal is afterwards poured out into moulds and makes a special kind of steel suitable for special purposes. We call it **cast steel.**

II. HARDENING AND TEMPERING THE STEEL

If steel is heated and then suddenly cooled by plunging it into water, it becomes exceedingly hard and brittle.

The workman can entirely change the character of the steel by raising it to a certain heat and then suddenly cooling it. This he calls **hardening** the steel.

This hardening makes the steel very brittle. The brittleness is removed by another process called **tempering,** in which the metal is heated and left to cool more slowly.

If the workman is preparing very hard steel for knives, razors, and other cutting instruments, he knows just **the heat** which is required; and if, on the other hand, he wants tough, elastic steel for springs, he knows how to alter the heat.

Steel when it is **being heated changes its colour** as it gets hotter, and this is a great help to the workman. He can tell by the look of the steel how hot it is.

Put one or two steel pen nibs in the bowl of a tobacco-pipe and hold it in the middle of a very hot fire. Take it out and throw the red-hot nibs suddenly into cold water.

They are now exceedingly brittle and so hard that we can scratch glass with them. They were not like this before. The heating and sudden cooling have changed them.

Now heat them again and leave them to cool gradually. Show that the nibs have now become soft and so flexible that they will readily bend. Twist one of them up in the fingers to show this.

Steel, then, is made hard and brittle, or tough and elastic, according to the purpose for which it is required, and it is made so by these processes of **hardening** and **tempering.**

Tell of some of the great iron factories where steel tools are worked by enormous steam-engines and made to cut through solid iron, pierce it with holes, or plane it smooth as easily as a carpenter cuts, pierces, and planes a piece of wood.

How sharp such tools must be; and to be sharp and to keep their sharpness, how hard the steel must be!

Refer to cast iron, and make the class tell why we call it by that name.

How are different articles made of cast iron? The metal is melted, and while in that state poured into moulds and left to cool.

Why don't we send cast iron to the blacksmith for him to work up at his forge? It is not malleable; it is very brittle; it won't be hammered.

Cast steel is as readily **fusible** as cast iron, but it is also as **malleable** as **wrought iron.** It can therefore be used for casting or moulding purposes, or it can be heated to redness in the forge and then **worked up, beaten, welded, rolled,** or **cut** just as we treat wrought iron.

Our **great guns** are made from this cast steel. It is also used for making **bells, machinery, railway wheels, fenders, fire-irons,** and many other things.

That which is wanted for other purposes is not melted in crucibles, but is heated and welded and rolled again and again, as the wrought iron was served in the puddling-furnace. We call this **shear steel.**

Shear steel is used for making knives, scissors, and all kinds of cutting instruments and tools, as well as springs for watches, boxes, doors, carriages, etc.

Show a watch-spring and the spring of a lock.

What is the special property of these? They are very **elastic** and spring back when pulled.

Let the children examine and see for themselves.

Show next a carpenter's chisel, a razor, or some other cutting instrument.

Is this required to be elastic and to bend and spring back? No.

We want a cutting instrument to keep a sharp edge.

What kind of metal ought we to use for such an instrument? A very hard metal. Just so; and the steel which is used for this purpose is very different from that from which springs are made.

Both are made from shear steel, but the steel is treated differently for the two purposes.

Lesson XIII

COPPER

I. PROPERTIES

SHOW a piece of polished copper, or, if possible, a polished copper utensil of some sort. Let the children handle and examine it and compare it with the iron and steel of last lesson, and then lead them to tell of its properties.

1. **Colour.**—What is the first thing you notice? It is not the same colour as iron and steel. It is a **bright red colour.**

Tell that copper is the only red metal we have.

2. **Lustre.**—What else can you tell me of copper? It has a bright polished surface. What name do we give this? Lustre. Copper, when well rubbed, **has a very bright lustre.**

3. **Weight.**—Now take this piece of copper in one hand and a similar piece of iron in the other.

Which is the heavier? **Copper is heavier than iron.**

4. **It is poisonous and rusts easily.**—*Warm the piece of copper at the fire. Now smell it. Put it to the tongue and taste it.*

What have you found out? **Copper when it is warmed has a disagreeable smell** and a **very nasty taste.**

Rub the copper and you will see that it has the same effect as warming it by the fire. It has that nasty taste because copper is poisonous.

Here is a piece of copper which has been lying in a wet place.

Do you notice anything about it? Yes; that green is copper rust. It is a very poisonous substance. We call it **Verdigris.**

Write the word on the black-board and show the application of the name.

See how quickly copper rusts. I poured a few drops of vinegar on this piece a minute or two ago. Look at the bright green patches of poisonous rust on it now.

5. **It is malleable.**—*Show a piece of very thin copper-foil.*

Now who can tell how the copper was made into thin sheets like this? It was done by rolling or hammering the metal.

What do we say about metals that can be beaten, rolled, or hammered out into sheets? They are **malleable.**

Copper is one of the most malleable of all metals. It can be beaten into very thin leaves.

6. **It is ductile.**—*Here is some copper wire. Show some of various thicknesses.*

What can you tell me about metals which can be drawn out into wire? They are **ductile.** Copper is a very ductile metal. It can be drawn out into finer wire than any other metal, except gold, silver, and iron.

7. **It is tenacious.**—*Take a piece of the wire and bend it, twist it, pull it in all directions.*

Does it break it? No.

What can you say about it, then? Copper wire is very

flexible, because it bends easily; it is very **tenacious,** because it does not break, but holds firmly together.

8. **It is sonorous.**—*Now take this piece of thin sheet-copper, hold it lightly, and strike it with this stick.*

What do you notice? It gives out a loud ringing sound.

We therefore say it is **sonorous,** which means **loud-sounding.**

II. ALLOYS OF COPPER

Tell that copper is fusible at a strong red heat, and that when melted it will readily mix with other metals.

What do we call the new metals which are made by melting and mixing together other metals in this way? We call them **alloys.** Copper is used in making several alloys.

1. **Brass.**—*Show some common article made of brass.*

Here we have a bright yellow metal.

Who can tell me its name?

Tell that brass is an alloy made by melting and mixing the two metals **copper and zinc.**

When the mixture cools, we have a fusible, malleable, ductile metal, capable of taking a very high polish. It is a very useful metal.

Call on the class to name articles made of brass.

2. **Bell metal.**—*Here is a bell. It is made of an alloy called* **bell metal,** *which is a mixture of* **copper and tin.**

Who can tell why copper is used for this? Because copper is a very sonorous metal.

3. **Bronze.**—Look at this penny. Of what metal is it made? Not copper. Many years ago, pennies, half-pennies, and farthings were made of copper, and people from habit sometimes call them coppers now. They are not made of copper, but bronze.

Bronze is an alloy made of **copper, tin, and zinc.**

Tell the other uses to which bronze is put, and that it was once used for swords, spears, etc.

Copper is also used in making the best sort of **pewter, nickel or German silver,** and other alloys.

Show a sovereign and a shilling.

What are these coins made of? They are not made of pure gold and silver. They would be too soft and would not stand the wear and tear. In each case a little copper is melted with the other metal, so that our sovereign and shilling are both made of alloys.

III. USES OF COPPER

We have seen that copper is a most useful metal when formed into alloys with other metals. It is also very useful in its pure state. It owes its usefulness to its malleable and ductile properties.

It can be rolled out into thin sheets, which are afterwards worked up into articles such as **kettles, sauce-pans, scuttles,** etc.

Copper sauce-pans, stew-pans, etc., should be lined with tin inside, and should always be kept dry and clean. Why?

Copper sheeting is also used for outer coverings to wooden ships. Here the poisonous rust is actually a good thing, for it kills all the water-plants and animals which would otherwise fasten on the bottom of the ship and prevent her moving quickly through the water.

IV. HOW COPPER IS OBTAINED

Copper is dug out of mines in the earth. It is sometimes found in a nearly pure state, but, like most metals, it is more frequently mixed with other substances.

Show some specimens of copper ore, and tell briefly of the process and the purpose of smelting.

Lesson XIV

LEAD

I. Properties

Show a piece of lead and let the children examine it for themselves, comparing it with the iron and copper of previous lessons.

1. **Its colour.**—*They can tell something of its bluish-grey colour and its dull tarnished surface. It has no lustre. We often speak of a leaden colour.*

2. **Its weight.**—*Compare it as to weight with iron and copper.*

Which is the heaviest? Lead is the heaviest of all the common metals. But it is not so heavy as gold.

3. **Its hardness.**—*Let one of the boys take a knife and cut the lead. Could he do this with the iron or the copper? He could never scratch the iron, but he could scratch copper.*

What can we say about the lead, then? It is a very soft metal.

Call attention once more to the newly-cut edge, and let the class explain that this bright surface will soon become dull like the rest.

The dull coating is really a thin coat of rust which covers the surface when lead is exposed to the air.

4. **It is malleable.**—*Show some sheet-lead.*

How was this made? The lead was rolled or hammered out into thin sheets.

What have we to say about the lead, then? It is malleable.

5. **It is not tenacious.**—*Let a boy come to the front and beat a piece of lead with the hammer. He flattens it out, but he finds that it easily breaks into pieces. It does not hold firmly together.*

What do we say about the lead? It is not tenacious.

Tell that this is why lead is not used for wire. Lead is not tenacious, and as soon as the wire is drawn out beyond $\frac{1}{12}$ *of an* *inch thick, it breaks. Even a thick lead wire would soon break with pulling.*

6. **It is flexible.**—*Bend an ordinary piece of lead piping by striking it on the edge of the table.*

It bends easily.

What do we say of it? It is flexible.

7. **It is fusible.**—What happened when we held some lead in the spoon over the flame? The lead melted.

Lead is more easily fused or melted than most of the other metals. It is very fusible.

II. ALLOYS OF LEAD

1. **Pewter.**—*Show a pewter spoon.*

Who knows what this is made of? It looks like lead, but it is not lead. It is made of an alloy of **lead and tin.** We call it pewter. It is largely used for making **measures** and **drinking-vessels** for beer and other liquids.

2. **Type-metal.**—I have here some little blocks with letters cut upon them. Can you tell me who uses them? The printer. He puts the letters together to form words, and uses them to print our books.

We call them type; and because they are always made of one metal, we call this **type-metal.**

It is an alloy made by fusing **lead** with a metal called **antimony.** The lead itself is too soft for the purpose, but the antimony hardens it.

3. **Solder.**—Refer again to the common solder used by the tinman.

Make the class tell the use of solder. Illustrate by joining two pieces of "tin" plate.

III. USES

The uses to which we put lead depend upon its fusible, malleable, flexible properties, and to the fact that it is so soft that it can be readily bent, cut, or formed into any required shape.

Show a piece of sheet-lead.

Tell that it is used for covering the **roofs of houses,** *making* **gutters, lining water-cisterns,** *and such like purposes.*

Lead is specially adapted for this purpose by the ease with which it can be cut, bent, or hammered into shape.

Sheet-lead is made in two ways.

Sometimes the melted lead is poured out on a flat surface of sand and rolled with wooden rollers to make it smooth and keep it the same thickness.

Sometimes the lead in the ordinary cold state is rolled between heavy steel rollers worked by steam-engines.

Show some lead-foil, such as is used for lining tea-chests. Tell that this very thin sheet-lead was made in a country a long way off, called China.

We get our tea from China. The people there make this thin lead sheeting by pouring the melted lead on a large flat stone and then pressing another flat stone upon it.

Show again the piece of lead piping. Tell of its use for gas and water pipes in our houses and other buildings.

Show one or two bullets and a few small shot.

What are these things used for?

Let the children tell what they know of them.

They are made of lead, but as the lead is too soft, another metal called **arsenic** is alloyed with the lead for this purpose.

IV. How Lead is obtained

Tell that the lead-ores usually contain, besides earthy substances, a small quantity of silver.

Show a piece of the common ore.

The metal is obtained from the ore in the usual way by smelting in very hot furnaces, the melted lead sinking to the bottom.

Lesson XV

TIN

I. PROPERTIES

SHOW a piece of polished tin. Tell its name. Let the children handle and examine it for themselves. The properties should be questioned out as far as possible, the teacher supplying where the class fail.

1. **Colour and lustre.**—What is the first thing you can tell me about this new metal, tin? It is white like silver and has a very bright shining surface.

What do we call this bright surface of a metal? Its lustre.

Tin has a very bright metallic lustre. If we look at it in one particular way we shall see there is a slight tinge of yellow mingled with the silvery white.

2. **Weight.**—*Now take it in your hand and compare it as to weight with iron, copper, and lead. Compared with lead, tin is a very light metal; it is also lighter than copper or iron.*

3. **Hardness.**—Look, I can easily cut through the metal with this knife.

Chip off a piece to show this.

What can we say about tin, therefore? It is a soft metal.

Cut a piece off the lead in the same way; scratch the lead with a nail, and show that this cannot be done with the tin.

Tin, therefore, although a soft metal, is not so soft as lead.

4. **It does not rust easily.**—*Show a* "**tin**" *vessel of some sort that has been allowed to stand in a damp place for some time.*

What should we have seen had this vessel been made of copper, iron, or steel? It would have been covered with patches of rust.

Is there any rust on the tin? No, tin does not readily rust when exposed to the damp or the air.

5. **It is malleable.**—*Show a piece of tin-foil. Let the class notice how very thin it is. Tell that it would take* 1000 *sheets of this tin-foil laid one upon another to make a pile one inch high.*

How was this tin-foil made? The tin was beaten or rolled out.

What do we say about metals that can be beaten or rolled out? They are malleable.

Tin, then, is malleable. It is, in fact, the most malleable of all the common metals except copper.

We have already found one metal which is not useful for making wire, viz. lead.

Why is this? Lead is not **tenacious,** its particles do not hold together.

Tin has not more tenacity than lead. Hence, although it is moderately **ductile** and can be drawn out into wire, such wire would be of little use, because it would very easily break.

Tin, then, like lead, is not useful for making wire.

6. **It is easily fusible.**—*Put some chips of tin into the spoon and melt over the flame of the Bunsen burner, or over the fire, to show how easily* **fusible** *this metal is.*

Tin is the **most fusible** of all the common metals.

II. Uses

We seldom find articles made of pure tin. Tin is nearly always used with other metals.

1. **Tinned ware.**—The commonest form in which we meet with tin is in our so-called "tin" ware.

Make the class tell what the tin sauce-pans, kettles, pans, etc., really are.

The tin-plate, or rather the "tinned" plate of which they are made, is not tin at all, but sheet-iron coated with a layer of tin on both sides.

The class should tell how this is made.

Tin being **easily fusible** can be used in its melted state for this purpose.

What good purpose does the tin coating serve?

2. **Tin lining for copper ware.**—*Make the class tell that copper sauce-pans, kettles, pans, etc., are also coated with a lining of tin on the inside.*

Why would the copper vessels be hurtful without this tin lining? Copper soon rusts on exposure to the air or to moisture, and the rust of copper is a dangerous poison called **verdigris.**

Why do we use tin to coat the copper? Because tin does not readily rust.

3. **Tin-foil.**—This is really sheet-tin, as thin as paper. We might call it tin-paper. How is it made?

Make the class recapitulate.

It is largely used for wrapping up sweetmeats, chocolate, fancy soaps, tobacco, and all articles that require to be kept from the air. The tin-foil is very **pliable** and folds closely over articles.

Show a packet of sweetmeats.

4. **Alloys of tin.**—Tin is used in forming some very important alloys. The commonest are bronze, pewter, bell-metal, solder. All these have been dealt with in former lessons.

Recapitulate. Make the children tell of the peculiar properties of solder; how they are secured; why they are necessary for this special purpose; why tin itself would not do the work, and so on.

III. HOW TIN IS OBTAINED

Like the other metals, tin is dug out of deep mines in the earth. It is not found pure, but mixed with other substances. In this state it is called **tin-ore.**

Show a specimen and let the class examine it.

The metal has to be separated from the ore by **smelting,** much in the same way as the iron was obtained in the blast-furnace. It is useless till the earthy matters have been removed from it.

Lesson XVI

ZINC

I. PROPERTIES

SHOW a piece of polished zinc. This is a new metal to us. Tell its name, and question out as far as possible the following properties.

1. **Colour.**—*Call attention to its colour and let the class compare the zinc with some of the other metals.*

How shall we describe colour ? Not dull grey like lead, nor yellowish-white like tin, nor pure white like this new shilling. It is a **bluish-white** metal.

2. **Lustre.**—Look at its bright polished surface. Zinc has a high metallic lustre when polished. Here is another piece of zinc which, a day or two ago, was as bright as this piece. Is it bright now ? No.

It is dull, tarnished, and rusted. This piece was set aside in a damp place, and in the damp it slowly tarnished and became covered with a thin coating of rust as we see it now.

3. **It rusts only on the surface.**—It is an important property in zinc that when once it becomes covered with a thin coat of rust like this, it will not rust any further. It seems that the thin coating all over the surface protects the metal from any further action of air or damp. The rust does not eat into the metal.

Compare with copper and iron. Show a piece of rusty iron. The rust has eaten into the metal so far that we can easily bend and break it. This never happens with zinc.

4. **Its weight.**—Let the boys compare it as to weight with copper, lead, iron, and tin, taking pieces of equal bulk.

Lead is heavier than zinc. Now try copper. Zinc is lighter than copper. Lead and copper are much heavier than zinc.

Now let the children try to find the lightest of the three—iron, tin, zinc.

It is more difficult to tell because there is not so much difference in weight between these three.

But **zinc** is really **the lightest** of all the common metals. Zinc is lighter than tin, tin than iron, iron than copper, and copper than lead.

5. **It is fusible.**—Zinc, like all other metals, is fusible, but it does not melt so easily as tin or lead. If we hold some zinc in the iron spoon over the fire we shall find that the spoon will get red hot before the zinc melts; but it does not require so much heat as copper.

6. **Its hardness.**—*Now take this knife and try to cut the zinc as we cut the tin and the lead. Let me try.*

See, even I find it much harder to cut the zinc than the lead and tin.

Still I can chip off little pieces of it.

Zinc is **harder than either lead or tin.**

Show next, by scratching it with a nail, that it is not so hard as iron.

7. **Zinc is malleable.**—Here is some sheet-zinc. How was that made? It was rolled or hammered out. What does that teach us? **Zinc is malleable.**

Bend the sheet a little. Show that it bends readily enough, but that when you let go it springs back.

Zinc is **flexible,** because it bends easily; and it is **somewhat elastic,** because it springs back.

Tell that zinc sheeting is more elastic than tin or lead, but not so elastic as either copper or iron sheeting.

Like tin and lead, zinc is not useful for making wire, because it is **neither ductile nor tenacious.**

II. USES

Zinc is a very useful metal, and its usefulness depends upon the properties we have been finding out.

It is malleable and can be made into sheets.

It is lighter and harder than lead, and it bends easily.

Water and air do not rust it, except on the surface.

For these reasons sheet-zinc is largely used for **gutters, rain-water pipes,** and for covering the **roofs of houses.**

Zinc does not cost so much as lead.

It is also used for making **baths, cans,** and other vessels for holding water.

Show a piece of zinc perforated with holes. This is very largely used instead of wire gauze for **food-safes, window-blinds,** *and other purposes. It does not rust, and the* **holes admit light and air.**

On account of its hardness and because it does not rust, zinc is made into **saws** for sawing up blocks of salt. Iron or steel would not do as well. They would rust.

Show a common galvanised iron pail.

What is this made of?

Tell that it is actually made of iron. We call it **galvanised iron.** *But it is not the colour of iron. It is just like this piece of zinc.*

This galvanised iron is made much in the same way as the "tinned" ware is made. The iron articles or the sheets of iron are dipped into a bath of melted zinc, which forms a coating all over them when cool.

Why is a zinc-covered pail better than one made of ordinary iron? The common iron would rust away, but **zinc does not rust below the surface.**

Alloys of Zinc.—Neither zinc nor lead is a ductile metal, but we have already learnt that when metals are melted and mixed together they form an alloy with new properties. These two metals are mixed in this way to make an alloy so ductile that it is made into a very useful kind of wire.

Show a piece. Tell that the gardener uses it to tie up the trees and shrubs in the garden, because it is very soft and will easily bend.

Draw from the class that iron wire would rust, copper wire is very dear, and string would soon perish.

Large quantities of zinc are used in making that beautiful and useful alloy, **brass.**

III. How Zinc is obtained

Show specimens of the ore, and tell that zinc is never found in the pure state, but always mixed with **sulphur and other substances.**

The method of separating the metal from the ore is too intricate to be described now.

Tell that, like iron, when it is first cast, zinc is brittle and cannot be beaten, because it is not malleable. The cast zinc has to be made malleable before it is fit for use.

Lesson XVII

SILVER

I. Properties

Show a new silver coin or some bright silver article, and, as in previous lessons, proceed to draw out, one by one, the properties of the metal.

1. **Colour.**—Silver is of a pure white colour.

Compare it with the whiteness of tin and zinc, and make class tell the difference.

2. **Lustre.**—Silver when polished has a very brilliant lustre. Tin is the nearest approach to it in colour and lustre, but when the two are placed side by side the tin appears quite dull against the highly polished silver.

Show a piece of polished tin and let the boys examine it.

3. **Weight.**—Silver is heavier than any of the common metals, **except lead.**

If possible, let the children compare discs of other metals equal in size to the silver coin.

4. **Hardness.**—Silver in its pure state is so soft that it can be easily scratched; it can even be cut with a knife. It is softer than copper. Pure silver would not be fit to use. It would soon wear away.

This coin is not made of pure silver. Who can tell what it is? It is an alloy of silver and copper. Why is copper used? Copper is harder than silver, and makes the alloy hard.

Tell that for our coins about 11 *parts of silver are melted and mixed with* 1 *part of copper. This makes the silver hard enough, but does not change its colour or lustre.*

5. **It is malleable.**—*Show a leaf of silver. Tell that silver can be beaten out into leaves so thin that* 10,000 *of them resting one upon another would only make a pile one inch high.*

This shows us that silver is very malleable. It is more so than any of the metals we have examined, but it is not so malleable as gold.

6. **It is ductile.**—*Show a piece of very fine silver wire.*

What do we learn from this? Silver is ductile and very tenacious.

Lead the class to tell that both properties must go together, or the wire would have broken long before it was drawn out to such a fineness.

A pound weight (Troy) of silver can be drawn out into a wire more than 440 miles in length. A single grain will make a wire nearly 400 feet in length.

7. **Silver does not rust.**—*Show a coin that was purposely left in the open air all night.*

Is it rusty? No, it is quite bright.

Show a steel knife that was placed beside it.

Silver may be exposed to the air or even to the action of water without rusting or even tarnishing. But silver **cannot resist sulphur** in any form.

Show a silver coin that has been lying in a drawer with some sulphur. Tell that this coin was bright and new when put into the drawer.

Make the class describe it now. It is like a dull, dirty, leaden coin. The sulphur has tarnished it.

Show a silver spoon which has been used in eating an egg. Tell that the yolk of the egg contains sulphur, and that it is the sulphur from the egg which has tarnished the spoon.

The fumes from our fires and from burning gas also cause silver to tarnish.

If kept from these things, silver will remain bright and untarnished, because it will not rust as other metals do merely from the action of air or damp.

How do we describe silver because it does not rust or tarnish in the air as the common metals do? We call it a **precious metal.** Another precious metal? Gold.

8. **Silver is tasteless.**—*Let one of the boys put the bright silver coin to his tongue. Draw from him that he tastes nothing, neither does he detect any smell in the silver. Refer to copper with its nauseous taste and smell.*

II. USES

We have seen that silver (or rather the alloy of silver and copper) is used for making our **coins.**

Make the class tell the names, and give the value of the various silver coins. Show as many as possible.

Why do we use silver rather than tin, zinc, or copper? Silver is not so plentiful as these common metals. It is worth more.

Place a silver sixpence side by side with six penny pieces, and show what a heavy weight of metal we should have to carry about with us if all our coins were made of bronze.

Silver is also used for making **plate** and **ornaments** of all kinds. The use of silver for these things depends upon its pure white colour and its brilliant lustre, which make it very beautiful to the eye.

It is so easily malleable that it can be beaten out into sheets, and worked up into all kinds of vessels and ornaments.

It is well fitted for making **spoons, forks, and drinking-vessels,** because it is without either taste or smell, and is not acted on by our food.

III. HOW SILVER IS OBTAINED

Silver is found almost in the pure state, and also in the form of ore. Lead and copper are frequently found mixed with the silver.

Whether mixed with other metals or with earthy matters, the silver must undergo a long process of **refining** before it is quite pure and fit for use.

Lesson XVIII

GOLD

I. PROPERTIES

SHOW a new gold coin, a watch, a chain, or some gold ornament. Let the class find out the properties of this metal as in former lessons.

1. **Colour.**—Gold is a yellow metal. Gold, in fact, is the only yellow metal we have. Call attention to some brass article lying on the table. Is not the brass yellow? Yes, it is very much like gold in colour. Why then do I say gold is the only yellow metal? Brass is not a pure metal. It is an alloy of copper and zinc.

2. **Lustre.**—*Call attention to the polished surface of the new sovereign. Let the boys explain that gold has a very high metallic lustre.*

Brass has a very brilliant lustre when it is polished, but how does it differ from gold? Brass soon loses its lustre, then tarnishes and rusts; gold never rusts nor even tarnishes, either in the air or from damp.

What name do we give to gold because it neither rusts nor tarnishes—because it is unchanged by air or damp? We call it a **precious metal.**

Who can remember what happened to the piece of copper when we poured a drop of vinegar on it? A large spot of green rust appeared on it.

Suppose you were to leave a steel knife in some vinegar, or even cut an apple with the knife, what would happen? The knife would rust.

Now I want you to remember that gold cannot be rusted or tarnished, even by acids much stronger than vinegar.

3. **Weight.**—*Let the children compare a sovereign and a shilling as to weight, and then, if possible, let them extend their comparison to some of the other metals. Lead them to tell that gold is the heaviest of all the metals we have examined.*

4. **Hardness.**—When pure, gold is almost as soft as lead, and can be easily cut with a knife.

Like silver it is too soft to be used in the pure state for **coins, rings, watches, chains, ornaments,** and other things.

It has to be alloyed with some other metal to harden it.

5. **Malleable.**—*Show some gold-leaf. Tell that* 282,000 *such leaves lying one upon another would make a pile one inch high.*

How many leaves of silver would make a similar pile? About 10,000 leaves.

That is to say, gold can be beaten out into leaf many times as thin as the finest silver-leaf.

What shall we say about gold? It is very malleable. **It is the most malleable of all the metals.** A single grain of gold (show the size) can be beaten out into a leaf large enough to cover one of your slates (60 square inches).

6. **Ductile.**—*Show, if possible, a piece of* **gold wire.** *Tell that gold can be very readily drawn out into wire.*

A grain of gold can be drawn out into a wire nearly 500 feet long. What shall we therefore say of the gold? It is very **ductile.**

7. **It is tenacious.**—One reason why gold can be beaten out into such thin sheets is that it is soft.

But lead is even softer than gold.

Can we beat lead out into such thin sheets as gold? No.

Why is this? The lead will not hold together.

It would after a time be beaten into holes.

How is it that the gold is not beaten into holes? Because gold is **very tenacious**; its particles hold firmly together.

It is because it is tenacious as well as soft that gold can be beaten into leaf, and drawn out into wire.

8. **It is scarce and therefore very valuable.**—*Show again the sovereign, and discs of any of the other metals at hand. Lead the children to tell that one would pass by these pieces of metal if he saw them lying on the ground. They would be scarcely worth the trouble of picking up.*

Suppose he found a sovereign. Think of the many good and useful things he could buy with that.

Why is this?

Tell that gold is not so plentiful as the other metals. It is found only in a few places, and is very hard to get. That is why so small a piece is worth so much.

Tell how much lead, tin, copper, iron, zinc, or brass we could buy for this little round piece of gold.

II. USES

Gold, from its great value, its beautiful appearance, and its power of always keeping a brilliant lustre, is specially fitted for ornaments for the person.

From the earliest times gold has been used for this purpose.

Call upon the class to mention such ornaments—**chains, rings, brooches, ear-rings, bracelets, pins, etc.**

Lead them to see that the ready malleability of gold fits it for these purposes.

It can be beaten, rolled, cut, twisted, or worked up into whatever shape the workman wishes.

It is used in all civilised countries as the principal metal for making coins.

For this and other purposes pure gold is not used, as it is too soft.

This sovereign is made of an alloy formed by melting and mixing 22 parts of pure gold with 2 parts of copper.

This alloy is always known as **standard gold,** and not only sovereigns and half-sovereigns but all our best ornaments, plate, and other articles are made of **standard gold.**

Call attention to some beautifully **bound book** *with its* **gilt edge, lettering,** *and* **ornaments,** *to the* **gilt lettering** *over shops, to* **gilded picture frames,** *etc.*

Are these made of gold? No.

Why not? Gold is too valuable to be used for large articles like these.

How are they made to look like gold, then? They are covered with some of that thin gold-leaf which we saw just now.

III. How Gold is obtained

Gold is not found, as other metals are, in the form of ores mixed with earthy substances. It is usually found in little round grains, called **nuggets,** in an almost pure state in the midst of hard rock.

The gold is obtained by crushing up the rock very fine, so that the bright shining grains of metal can be easily seen and picked out.

LESSONS FROM PLANTS

Lesson XIX

STARCH

I. Properties

Hand a few sticks of common starch round the class for examination.

You can all tell me what this is. Where have you seen this substance before?

Lead the children to tell of the use of starch for **laundry purposes.**

Now examine your pieces of starch and let us see what we can find out about this new substance.

1. **Colour.**—It is a white substance, something like chalk; but if we compare the starch with a piece of chalk we shall see that the starch is a more brilliant white than the chalk.

2. **Hardness.**—*Now scrape one of the sticks with a knife, drop it on the desk, or break it with the fingers.*

What can you tell of the starch now? It is a soft substance, because we can easily scrape or cut it with a knife.

3. **Brittle.**—*Take some of the starch and rub it between your fingers.*

It is so brittle that it at once breaks up into small particles and can be readily made into a powder, and while it breaks up it gives out a peculiar, harsh, crackling sound.

4. **Soluble in boiling water.**—Here we have a piece of sugar and some salt.

What would happen if I put them into this glass of water? They would dissolve.

Why? Because sugar and salt are soluble in water.

Now, instead of sugar or salt, I will put this piece of starch into the water.

Tell me what happens? The starch sinks to the bottom of the glass.

What does that tell us? That the **starch is heavier than the water.** No change takes place in the starch; it lies at the bottom of the glass just as we put it in.

Why is this? Starch is **insoluble.**

Mix the starch well with a spoon, and show that it makes a thick, chalk-like mixture, which we cannot see through.

Would it have been so with sugar, salt, or alum? No.

Why not? Because the water would dissolve them.

Let part of the starch mixture be set aside for a while to be examined again.

Pour some boiling water on the rest, and make the class describe the change it undergoes.

It swells up into a sort of thick jelly or paste. The hot water has dissolved or broken up the starch.

Let the children examine the pasty, jelly-like mass for themselves. Continue to add hot water, and the whole will become a thin, nearly transparent liquid. **The starch is dissolved.**

So then, starch is **insoluble in cold** but **soluble in boiling water.** Look now at the mixture we made in the cold water. Most of the solid particles of the starch have settled down at the bottom of the glass, leaving the water clear as it was at first.

When it has all settled, we can if we wish easily drain off the water and **recover our starch** again. It was not dissolved.

The starch in the hot water will not settle at the bottom.

Your mother uses the starch, dissolved in boiling water, to make your linen collars stiff. She then irons them with a hot iron to **drive off the water,** and the jelly-like starch fills up the pores of the linen and gives it a gloss.

II. PREPARATION

Take a little wheaten flour, mix it into a paste, and tie it up in a piece of muslin or cambric.

Hold it in a vessel of water and **knead it between the fingers and thumb.**

Let the class tell what they observe.

The water assumes a white, milky appearance.

Explain that this flour—the flour we use for making our bread, puddings, cakes, etc.—contains a very large quantity of starch.

The white, milky appearance of the water is due to the starch, which is being washed out of the dough.

Continue to work the bag until all the starch has passed out into the water. Then set the vessel aside, and allow the starch to **settle at the bottom.**

Tell that when the whole of the starch has settled, the water will be quite clear and can be poured off, leaving the starch behind.

Or the starch may be collected by **filtering and drying over a gentle heat.**

Show some which has been prepared previously, and let the children examine it and compare it with the sticks they handled first.

Prepare also **from the potato** *in the following way:—*

Rasp a clean potato into a pulp, and tie up in a muslin bag as before. If the bag be worked between the thumb and fingers, as in the previous experiment, the starch will pass out into the water and give it a milky appearance.

Potatoes contain a large amount of starch. The starch can be collected by filtering or by pouring off the water.

In this country nearly all the starch we use is made from wheat or rice flour. In America it is mostly made from **maize.**

Show a few of the grains.

In other countries the potato is chiefly used for this purpose.

III. BRITISH GUM

Call attention to the adhesive side of the postage-stamp.

What is the object of this? To make the stamp stick to the letter. Something has been put on the stamp to make it stick. That something is a substance which we call British gum. Let us see what it is.

One of the properties of starch is, as we have seen, that it is insoluble in cold water. Now if dry starch is baked in an oven, it loses this property. It turns brown and becomes easily soluble. It forms this new substance, **British gum** or **dextrine,** which is useful in very many ways.

1. **As an adhesive substance.**—British gum, when pasted on the back of postage-stamps, labels, envelopes, quickly dries and requires only to be moistened to make it stick fast as a **cement.**

2. **As a size for paper.**—*Refer to the lesson on "Porous Substances." Compare* **blotting** *with* **writing paper.**

How is the difference brought about? The pores of the writing-paper have been filled up with **size.**

This size is made of British gum.

3. **As a size for calico.**—*Show a piece of new calico or print.*

Call attention to the smoothness and gloss on its surface. Rub it in the hands and show that the gloss is all gone.

Call attention to the white dust which has been rubbed out.

This dust is the dry size (British gum) which was used to give it a nice appearance.

Lesson XX

STARCH—*continued*

I. WHAT STARCH IS

OUR last lesson taught us that starch is prepared from wheat, rice, maize, and potatoes. Therefore we know it is a **vegetable substance**—a substance obtained from plants.

It is found in all plants. In some it is very abundant. The plants prepare this substance and store it up as a future supply of food for themselves.

Some plants store up the starch in underground tubers and roots, as the potato, arrowroot, carrot, beet, etc., some store it up in their stems, as in the sago plant (which we shall talk about presently), some in their seeds, as in the case of beans, pease, and the corn grains (wheat, barley, oats, rye, maize, rice, etc.)

In whatever part of the plant the starch is stored it is always met with in the form of tiny grains, too small to be seen with the naked eye.

They can be seen and examined only with the aid of a microscope, and then we find that they differ in size and shape according to the plant from which they come.

See, here I have some drawings of these starch grains as they appear under the microscope.

Compare the size, shape, and appearance of the grains of potato-starch, wheat-starch, maize-starch, and rice-starch.

These grains are all alike in one respect. They are all in reality little bags of actual starch.

Cold water has no effect on these starch grains, except to separate them from one another, so that they float about in the water and make it a thick milky fluid.

Hot water, on the other hand, causes the grains to swell up and burst, and then the true starchy matter within them is set free and becomes dissolved in the water, forming the jelly-like paste we spoke of in the last lesson.

The remarkable part of it is that these grains, once broken up by the hot water, can never be re-formed again.

Who remembers what happened when I put our solution of salt over the flame of the spirit-lamp? The water passed off and left the grains of salt behind.

It would be **impossible to recover the grains of starch** as we did the grains of salt.

II. Starch Foods

This starch which your mother uses to stiffen the shirts and collars, and which is useful, as we have seen, in many other ways, is one of the principal articles of our daily food.

We could not live without it in some form or other.

What should we be without our bread and puddings? They are made of wheaten flour, and this wheaten flour is useful because it contains a large quantity of starch.

People in other countries use barley, oats, rye, maize, or rice as their principal food. They do it because each of these contains the very thing they require—starch. Boys and girls in Ireland get less bread and pudding than you do, they live mostly on potatoes; but potatoes form good food, because they contain plenty of starch.

Sago.—*Show a handful and let the children examine it for themselves.*

We use it to make delicious puddings.

Sago is almost pure starch. It is **obtained from the soft pith** of a tree that grows in some very hot parts of the world. We call the tree the **sago palm.**

Be careful to see that the children clearly understand what is meant by the pith, and that it is found in the stem of the plant.

When the sago plant is fully grown it is a fine tree about 30 feet high and is just about to flower. These trees only flower once.

Just before this happens, however, the tree is cut down, and the soft, gummy-looking pith is removed from the middle of the trunk.

The pith is broken up into a coarse powder and then put into water, where it is **kneaded** and **pressed** and **strained,** until all the starch has passed out.

This is collected by allowing the water to stand and settle. It is then partially dried, and in this state **pressed through sieves** to give it the round, grain-like appearance in which we always see it.

Arrowroot.—*Show some and tell that this too is nearly pure starch.*

Let the children rub some of it in their fingers and note for themselves the peculiar **starchy** *feel it has.*

It is mostly used in the sick-room, as it is a light, easily digested food for invalids and children. This substance, although called arrowroot, is **not made from the root** of the plant, but from the **underground stem.**

This arrowroot plant, then, is useful to us for the sake of its underground stem.

When ripe it is found to contain a large quantity of starch, which it has stored up in the underground stem for its future growth.

It is then taken up, and after careful washing the **stem is peeled** and broken up into a kind of pulp in cold water. When it is left to settle, the starch sinks to the bottom, and the water is drained off.

Nothing remains but to **dry the sediment,** and then we have a beautiful, white, glistening powder such as we see here.

Tapioca.—*Show some. Tell that it is prepared from the root of a plant and consists almost entirely of starch.*

The roots when fit for use are found to be stored with starch for future supply.

They are then broken up, mashed into pulp, kneaded and strained, much in the same way as the arrowroot was treated.

The starch falls to the bottom, the water is drained off, and the sediment dried.

It is usually **dried on hot plates,** and as it dries it is stirred about with an iron rod. It is this which gives it its peculiar appearance.

The **tapioca plant is a deadly poison.** The wild Indians use its juice to poison their arrows. But the heat of drying the paste carries off all its bad properties, and the starchy matter left behind forms a wholesome food.

Lesson XXI

CORN

I. INTRODUCTION

SHOW some flour, and lead the class to recapitulate from last lesson some of its principal properties.

Make them tell that flour is a powder obtained by grinding the grains of wheat in a mill.

Show some wheat grains.

Where did these grains come from? They grew on plants in a corn-field. We are now going to learn something about these corn plants—what they are and how they grow.

II. CORN AND GRASS

Lead the children to talk about the grass in our fields and parks and gardens.

What a cool, smooth, and pleasant carpet it makes. The grass on our lawns we keep short and smooth by constant cutting, but the grass of our fields and meadows is allowed to grow very high.

What do we do with it? In the summer-time it is cut down and dried in the sun to make hay.

See, here I have some tufts of very tall grass. Let us examine them.

1. **Leaves and stems.**—The leaves are long, narrow, and pointed. We call them **blades** of grass.

Hold one of them up to the light. What do you notice now? That the veins run in parallel lines from the base to the point.

Now let us trace the leaves down from the point and we shall find the stem. Here it is.

Call attention to the tall, round stem, and show that here and there along the stem there are thick knots or swellings which we call **joints.** *The leaves all spring from the joints.*

Split up the stem with a knife and show that it is really a **hollow tube** *divided into lengths by partitions at the joints. Although hollow, it is very tough and strong and will not easily break. The knots or joints help very much to strengthen the stems.*

2. **Flowers and seeds.**—*Show a specimen of grass in flower.*

Call attention to its small green blossoms at the top of the stem.

When the flowers die off, they leave the seeds behind arranged in a long ear. The ear ripens, the seeds, which are very small and light, are scattered about by the wind, and thus the grass sows its own seed, which comes up next spring.

Now let the class examine the specimens of the corn plant. Starting with the leaves, show that they too are long, narrow, and *pointed, and have their veins running in parallel lines from base to point.*

They are in every respect like those of the grass which we have just examined, except that the blades of grass are tougher and coarser.

The corn leaves spring too from knots or joints in a round, hollow stem at the top of which grows the blossom or ear.

All this the class should be led to find out for themselves by actually handling and examining the specimens.

Each corn plant actually sends up five or six separate stems.

Call attention to the admirable arrangement of these long leaves, which are meant as a protection for the stem, with its delicate growing blossom, which is to become an ear of corn.

As the stem rises, the last leaf always enfolds it closely in a sort of sheath until the ear-blossom is able to brave the sun and the weather without protection.

Take an ear of corn from which the grains have been removed, and show that the ear is really the topmost extremity of the stem of the plant. The stem, in fact, runs through the middle of the ear.

Point out the little cases of thin, light, but tough material arranged all round the central stem.

These are the husks, which hold and protect the growing grain. When the ear is ripe these little cases split open and the grain is released.

The children will readily now understand that the corn plants and the grasses are members of the same family of plants.

We often speak of the corn plants as **corn grasses.**

III. KINDS OF CORN

1. **Wheat.**—*Show an ear and a few grains of wheat. Tell that wheat is the most valuable of all the corn grains. It is made into flour, and forms the chief article of our food.*

2. **Barley.**—*Show an ear of barley. Call attention to its long, pointed beard. Each grain ends in a long spike.*

Tell that barley is more hardy than wheat.

It will grow where it would be impossible to grow wheat. Next to wheat it is the most valuable kind of corn which we grow.

Barley is mostly used for making **malt**, from which **beer is made.**

It is also ground into a sort of flour called **barley-meal**, and is used for **feeding pigs and poultry.**

People do not use it for food if they can get wheaten flour, because the wheaten flour is best.

3. **Oats.**—*Show a bunch of the grain.*

Tell that oats will grow in much colder countries than wheat or barley.

Call attention to the arrangement of the grains—so different from that of wheat and barley.

The ears hang in loose, graceful, drooping bunches, and each grain hangs with its open end downwards, towards the earth.

Show how the grains are formed, and lead the class to reason out the special design in this arrangement as a protection for the grain against cold and wet.

Oats form a very wholesome and at the same time a very satisfying article of food. In countries where wheat will not grow, the people live largely on oats.

Instance the **oat-cake** *and the* **porridge** *of Scotland.*

We use oats chiefly for feeding horses.

4. **Rye.**—We do not grow rye for grain, as it makes a dark, coarse, and heavy bread. But in some countries the poorest class of people live on it. Rye in our country is grown for **cattle and sheep**, and is always cut while green.

IV. WHY WHEAT IS BEST

Refer to the experiment of getting the starch from flour. Make the class tell how it was done and what was the result.

Repeat the experiment now, but instead of noticing the starch sediment in the water, call attention to the **gluten** *left behind in the muslin bag.*

This gluten is a very important and **nourishing** article of food. It forms flesh.

Gluten can be obtained as well as starch from all the corn grains, but wheat is more valuable than the rest because it contains a greater quantity of gluten.

V. STRAW

Tell briefly of the harvest-field—the cutting of the corn—the threshing out of the grain.

What is left behind? The long yellow stalks—straw.

Make the children mention some of the common uses of straw, and lead them to tell of its use for making **plait** *for hats, bonnets, mats, etc.*

Lesson XXII

RICE

I. PROPERTIES AND USES

SHOW some grains of rice. Compare them with the common cereals—wheat, barley, oats, etc. Call attention to their **pure white colour** *and* **glistening** *appearance.*

Break them with a hammer, and show how brittle the grains are.

The rice grains consist almost entirely of starch.

Show some rice-flour and compare it with wheat-flour, barley and oat meals.

These all contain a large amount of starch; but they also contain another important substance—**gluten.**

Let the children tell how the gluten can be obtained from the flour—what it is like in appearance—why useful for food, and so on.

Rice contains a very **small quantity** of this gluten.

II. RICE AND WHEAT COMPARED

Repeat the experiment with some of the rice-flour, and show that when the kneading and pressing are over and the starch is all removed, nothing remains in the muslin bag. The rice-flour is **pure starch.**

The rice grains themselves before they were ground into flour did contain some very small amount of gluten.

The **gluten,** however, in all the grains—wheat, barley, oats, rice, etc., is always found on the **outer part** of the grain, just beneath the skin.

The miller, after grinding the grain in his mill, **sifts** the flour through close sieves to make it fine.

The little particles of outer skin and most of the gluten are left behind in the sieves, and nothing passes through but the fine particles of starchy matter.

Rice-flour is therefore **not fit** for making bread. It contains **no gluten.**

Refer again to the previous lesson. Wheaten flour makes excellent bread because it contains, not only starch, but also a large quantity of gluten, which helps to make our **flesh and bones and blood.**

Show some **bran,** *some* **entire wheat-flour,** *and some* **pure whites.** *Explain what each consists of.*

Some people like to have very **white bread.** Such bread is made of this very white flour.

The **entire wheat-flour** is not nearly so white and does not make such white bread.

Who can tell me why? It contains all the grain. The little particles of outer skin and the gluten have not been sifted from it.

Which bread, then, is best; the very white or the brown bread? The brown.

Why? The whiter the flour is, the less gluten it contains, and the less it is fitted for food.

Wheat-flour, then, makes good bread, but especially when **not sifted too finely.**

Rice-flour is not good for bread.

Rice is usually boiled whole and eaten with other kinds of food, and in this way it is **very light, wholesome,** and **easily digested.**

But it is not good to eat alone.

Rice is to the people in the very hot parts of the world as **important an article** of food as wheat is to us. The people of India and China eat it mixed with curry powder at every meal.

It is said to be the chief food of at least 100 millions of people. We use large quantities of rice now in England for **making starch.**

Who has seen the bills in the grocers' windows, "Best rice-starch"?

The **rice straw** is very fine, and is used for making **straw plait** for hats and bonnets.

III. HOW RICE IS GROWN

Show a picture of the rice plant. Call attention to its structure and appearance.

Lead the class to note the similarity between it and other corn grasses.

There is the same round, jointed stem, and if we had an actual specimen at hand, and could slit it down the middle, we should find it to be **hollow.**

The leaves spring from these joints, and they are long, narrow, and pointed, like those of the wheat plant.

The rice plant is one of the **corn grasses.**

Rice grows in the very hot parts of the world. It would not grow in our cold country. It grows best in places where the **soil is damp and marshy** and the air always hot and moist.

The plant requires a large quantity of moisture, and would die at once if it were allowed to get dry.

In some countries the rivers overflow their banks and cover the fields for miles. People there actually sow their grains in the water, and when the floods go down, the seeds sink into the soft mud at the bottom, and spring up there.

In other countries where the rivers do not help by overflowing, the people sow the seed in trenches, in the spring, and then flood the whole field with water. After several days the water is allowed to drain off, and the little plants are seen peeping up through the soft wet mud at the bottom.

When the plants are about four inches above the ground, the water is again let in and allowed to remain covering the field for about a fortnight. This is again repeated just before the grain ripens.

Picture the bright, hot sun in these countries, and tell how rapidly plants grow under such treatment.

Tell of the rice harvest—the ground soft and swampy from such repeated flooding—the reaper sinking deeply into the oozy mud at each movement with the sickle. It is **very unhealthy.** *Why?*

The rice when cut is enclosed in a brown outer husk.

Compare it with the grains in an ear of wheat.

Some of the rice is brought to England just as it is, husk and all. We then call it **paddy.**

Show a specimen.

The husk is removed by rubbing the grain between rough stones in a mill **without breaking** it.

In this state we call it **clean rice.**

Lesson XXIII

MAIZE

I. The Grain and the Ear

Show a few grains of maize side by side with some other cereals. Lead the children to compare them as to size, shape, colour. Tell that these grains are called **maize** *or* **Indian corn.**

A few varieties of the grain should be shown if possible.

Explain and show that they differ from each other, not only in size, but in colour.

Some are green, some orange, some white, some purple, some chocolate, and some striped.

Now show the **cobb** *or* **ear.** *Call attention to the round, pithy stem running upward from the stalk through the centre, with the rows of seeds set closely all around it.*

Compare it with the ear of wheat or barley and the hanging bunch of oats.

II. THE PLANT AND HOW IT GROWS

Show a picture of the plant. Call attention to the thick, strong, jointed stem. Tell that this stem usually grows from six to ten feet high.

Let the children show these measurements on the walls.

Point out the long, broad, tapering leaves which spring from the joints. Show that they are the same smooth, parallel-veined leaves as we met with in the other corn grasses.

Next call attention to the **bunch or tassel** *of peculiar flowers at the top of the stem, and just below it point out the* **ears,** *generally three in number.*

Show that each ear is enclosed in a sort of **sheath** *formed of two or three delicate leaves.*

Why is this? The leaves form a protection to the growing ear till it is able to take care of itself. When the covering is no longer necessary, the thin leaves split open and the ear stands exposed.

Show one in picture. Call attention to the long, silky thread which may be seen hanging from each grain in the newly opened ear.

Tell that, as the grain ripens, these silky threads wither and die off, and so does the tassel of flowers above them.

Lead the class to see, from all that has been told, that the maize plant belongs to the same family as the other corn grasses, although it differs from them in being taller and stronger in appearance.

This plant grows in the warm countries of the world, but will not flourish and ripen its seeds in such cold lands as ours. With rich soil and plenty of warm sun it is very easily grown, and it produces more grain than any other of the corn grasses.

It is called **Indian corn** because when white people first discovered America they found that the plant was grown there by the Indians.

III. PROPERTIES AND USES

Indian corn consists very largely of **starch,** and contains very **little gluten.** Hence it is not suitable for making bread.

Make the children again tell why gluten is necessary as well as starch for the purposes of food.

Now show some gluten (prepared beforehand), and lead the children to tell, by handling and examining it, its plastic and adhesive properties. It is as sticky as bird-lime.

Lead them to see that starchy flour, such as the flour of rice or maize, is not only unsuitable as a complete food, but that it cannot be formed into a loaf, because it has no sticky gluten in it to bind it together. It would crumble to pieces.

The people in America, where maize is largely grown, use it for making bread, but they **mix wheaten flour** with it for that purpose, because wheaten flour is rich in **gluten.**

Maize grows in such abundance in America, and produces so much more grain than any other kind of corn, that it is the **chief article of food.**

It is not only **cheap,** but it is very **wholesome.** It contains a large amount of **fatty oil,** and is hence very fattening both for cattle and people.

In America it is used in various ways. One kind, known as **sweet maize,** is cut while green and boiled as a **vegetable** for the table, as we use green peas.

The best of the grain is used for making **corn-flour.**

Show a packet.

Lead children to tell that we use it to make **puddings, custards, blanc-manges,** *etc.*

This corn-flour is really the maize-flour with all its **gluten removed.** It is **pure starch.** To **prepare the corn-flour,** the maize grains are first soaked in water till they swell up and become rather soft. They are then crushed between rollers in a tank of water. As the crushing process goes on, the water becomes white and milky-looking. Why?

Lead the children to see that the same process is at work as when we kneaded up the flour in the muslin bag. The water becomes milky-looking because it receives the starch which is being set free from the crushed grain.

When the whole of the grain is crushed fine, the milky-looking fluid in the tank is passed through sieves, but the husks and skins are held back.

Make the children tell that the **gluten** *of the grain is always found* **adhering closely** *to the* **outer skin or husk,** *and that, therefore, when the husk is held back in the sieve, the gluten remains with it.*

Nothing but the pure starch passes off with the water into the settling tanks below. The fluid is allowed to stand for a time until all the starch has sunk to the bottom.

The clear water is then drained off, and the starch removed and dried over a gentle heat. This starch is the corn-flour which we use for our puddings and custards.

LESSONS FROM ANIMALS

Lesson XXIV

THE COW

I. GENERAL BUILD

SHOW a picture of a cow and help the children to describe its general appearance.

By what other name do we call this animal? An **ox.** The cow is a **large, thick-set** animal, almost as big as the horse. It has a **short, thick neck,** and a **broad and deep chest,** and its **head is small** compared with its big body.

Call attention to the **broad, flat forehead**; *the pair of smooth, tapering* **horns**; *the large, gentle* **eyes**; *the broad, square* **muzzle,** *and the* **ears** *which it can raise erect in an instant.*

Tell that it is a very **timid, gentle** *creature, and that these large eyes and quick ears are intended to warn it if any danger approaches.*

In some countries oxen roam wild over the grassy plains, and they are always in danger of being killed by the fierce, flesh-eating animals around them.

It has a **thick skin or hide,** covered with short, close, smooth hair, like that of the horse. Its **tail** is long, and is furnished with a thick **tuft of hair** at the end.

Who has seen the cow on a hot summer day whisking its tail in all directions? Why does it do this? It uses its tail with the tuft of hair to drive off the flies which settle on its head and annoy it.

Next call attention to the **short, solid-looking legs,** *just fit to support so* **heavy a body.**

Lead the children to tell of the peculiar formation of the **feet.** *Refer to the lesson on "Sheep." Compare the feet of the sheep and cow.*

Both are divided by a deep **cleft** down the middle, really forming **two toes.** The inner surfaces fit closely together, as though the foot had been split down the middle.

Notice the hard, horny covering for the foot.

What do we call a foot covered in this way? A **hoof.**

What name do we give to a hoof split into two parts like those of the sheep and cow? A **cloven hoof.**

Cloven means split in two.

How many toes has the sheep altogether? **Four.**

There are two short ones behind. In walking, the sheep never touches the ground with these two hinder toes.

Tell that in every respect the cow's feet are like those of the sheep, and that in walking it treads only on the two front toes.

Explain the names **bull, bullock, cow, calf, steer, heifer.**

II. THE COW'S FOOD

Lead the children to tell from their previous knowledge of other animals how nature determines the kind of food by giving a particular kind of **teeth.**

We need not ask what food an animal eats, we have simply to examine its teeth and they will tell us. The cow has the same sort of **broad, flat-crowned teeth** as the sheep.

Show a tooth of this kind. What name do we give to such teeth?

We call them **grinders.** They crush and grind up the food as in a mill.

Lead the class to tell that the cow, like the sheep, feeds on grass.

Animals with large grinding teeth always have a peculiar movement of the lower jaw.

Who can explain it? They are able to move the jaw, not only up and down, but from side to side—in all directions.

Show that grinding teeth would be of no use if the jaw only moved up and down. It is the movement from side to side which actually does the grinding and crushing.

Do you remember anything particular about the upper jaw of the **sheep?** There are **no teeth in front.**

Instead of teeth, there is a thick **hard pad.**

How does the sheep use this pad? It collects up a mouthful of grass with its long tongue and lips, and the sharp cutting teeth in front of the lower jaw press it upwards against the pad, while the head gives a **sharp jerk,** and the bundle of grass is torn or cut off and swallowed.

Show that the **cow and sheep** *are* **exactly alike** *in* **all these particulars.**

III. CHEWING THE CUD

Refer again to the lesson on the sheep, and make the children describe, step by step, its mode of feeding, the teacher stepping in only to give **a hint** *or two to correct wrong ideas.*

Make them tell that the **great difference** *between a sheep and other animals is that it has* **four distinct stomachs,** *instead of one.*

Lead them to describe each of these—the **paunch,** *a bag for receiving the newly-cropped grass and passing it on to the next stomach; the* **peculiar structure** *of this, with its* **honeycombed walls,** *and the purpose of these; the work of mastication going on while the animal is at rest; the second swallowing into the* **third stomach,** *whence it passes into the* **fourth** *or* **true stomach,** *where the work of* **actual digestion** *goes on.*

Tell that, in every respect, the cow and the sheep are alike in their manner of feeding. We call it **chewing the cud,** *because the honeycombed stomach sends up the food in* **cuds or pellets** *into the mouth to be chewed.*

IV. USES

1. The cow gives valuable milk.

2. Its flesh is a valuable article of food—**beef.**

What is the flesh of the calf called? **Veal.**

3. Its skin is tanned into leather.

4. Its bones and horns are made into various articles of daily use.

Let the children name some of them.

5. Its fat gives tallow for making soap and candles.

6. The waste cuttings from skin, horns, and hoofs are useful for making glue.

7. In some countries the cow is used to draw waggons, carts, ploughs, etc., where we employ horses.

In some parts of our own country the cow may still be seen drawing the plough.

Lesson XXV

MILK, BUTTER, AND CHEESE

I. MILK AND ITS PROPERTIES

Hold up a glass of milk before the class.

What is this? We are going to learn something about it.

First of all look at it yourselves and try to tell me something about it. It is a **white liquid.** Let us compare it with this glass of water.

See, I will hold this ball behind the water. Can you see the ball? Yes.

Now I will place the ball behind the glass of milk. Can you see the ball this time? No. We can see through the water, but we cannot see through the milk.

In this way lead up to the words **transparent** *and* **opaque,** *and let the children give examples.*

Milk is a **white opaque liquid.**

Let them taste the milk.

It is **sweet and pleasant** to the **taste.**

Take two sheets of clean white paper. Pour a little milk on one, and some clean water on the other. Dry them both before the fire and let children examine them.

The milk has left a greasy stain on the paper, but there is none from water.

Milk, then, is a **fatty** or **greasy liquid.** When you were little babies, what kind of food did you have? Milk. Think of baby at home, how it grows and gets stronger day by day, and yet it takes nothing but milk.

Milk, then, must be a very **satisfying, wholesome,** and **nourishing food.**

II. USES

Lead the children to tell that in London and other great towns all the milk we get is used in its simple form.

We drink it, we put it in our tea, coffee, cocoa; we use it for making rice, corn-flour, sago, and tapioca puddings.

Lead them to explain that rice, sago, etc., are **starches** *and* **cannot form flesh.**

We mix milk with these starches because milk contains a large amount of flesh-forming material.

Lead the children to think of the milkman going his rounds morning and afternoon.

Whence does he get his milk? Most of it comes from the country.

Picture one of our great railway stations very early in the morning—the trains with their loads of tall, upright cans filled with milk—the bustle and the clatter. These cans have come from **farms** *in the country, where the farmers keep great numbers of cows, on purpose to supply us with milk.*

III. BUTTER

Show some new milk which has been left to stand for some hours in a shallow dish.

Call attention to the thick **cream** *floating on the top.*

Skim it carefully with a flat ladle. That left in the dish is **skimmed milk.**

Warm some cream slightly, put it into a warm soda-water bottle and shake it. Let the children note and tell what takes place.

The cream first of all collects in little lumps, then these little lumps gradually unite one with another as the shaking goes on, and the mass may be seen floating in a thin liquid.

The **solid lump is butter,** and we call the remaining liquid **butter-milk.**

Let me tell you how this change has taken place. The cream consists of a mass of very tiny **particles of fat,** each enclosed in an extremely **delicate skin.**

The object of the shaking is to break this delicate skin, and so set free the little particles of fat, which at once unite together in solid lumps.

Show a picture of a dairy—cool, shady, spotlessly clean; shelves round with a number of shallow pans filled with milk. Why? The milk is set to form **cream.**

The dairymaid skims off the cream with a **skimmer,** and puts it into a **churn.**

Show pictures of both upright and barrel churns and explain how used.

Tell that the same process of change goes on in the churn as we saw in the glass bottle.

When the dairymaid finds that the butter is properly formed, she takes it out of the churn and works it up with her hands on a cold stone slab to press out all the butter-milk.

Nothing now remains but to add a little salt, and the butter is ready for use. If it is to be kept for a long time, a larger quantity of salt is used, and we call it **salt butter.**

IV. CHEESE

Pour some vinegar or a little rennet into the glass of milk, and make the children tell what takes place. Instead of milk they see now some white, solid lumps, floating in a watery liquid. Tell the name—**curds** *and* **whey.**

Cheese is made from curds of milk.

Show some **rennet,** *and explain that it is obtained by cutting up the stomach of a calf and soaking the pieces in water. It has a* **sharp acid taste.**

Take some of the curd out of the glass, drain the liquid from it, and cut it in pieces with a knife. There is still a considerable amount of water in it.

Tell that if we could press out all the water we could make the curd into actual cheese.

Describe a cheese-press and the process of cheese-making as carried out in the dairy.

The milk is warmed and separated into **curds and whey,** with the help of rennet, just as we did it.

When the curd is formed, it is cut up into small pieces and stood aside for about half an hour **to drain.**

The pieces are then gathered up and put into a vessel called the **cheese-vat,** where the whole mass is pressed until all the water is squeezed out.

When this is done, the curd is taken out, cut up into small pieces, salted, and well mixed. It is then divided into portions, enough to make one cheese, and each portion is put into a **canvas bag** and placed in the cheese-press for several days.

Show picture of a press. When taken from the press they are arranged on shelves in a dry room and turned every day. In six months they are ready for use.

Lesson XXVI

THE HORSE

I. INTRODUCTION

SHOW a picture of a horse. Tell the subject of the lesson.

Lead the class to tell, from their own observation, such points as the following:—

The horse is a **large, strong** animal, larger than the cow; in nature, he is **quiet, gentle, obedient,** and very **sensible,** one of the most **useful** of all our domestic animals.

We do **not eat** its **flesh,** neither does it give us milk as the cow does. It is useful to man as a **beast of draught** and **burden.**

There are many different **kinds** of horses, each useful in its own way.

Lead the class to tell about **cart**-*horses*, **carriage**-*horses*, **hunters**, **race**-*horses*.

What do we call a **female** horse? A **mare.**

Tell the distinction between **colt, foal, filly.**

II. General Build

Question out the following:—

1. **The Skin.**—The horse's skin is not thick and hard like the cow's hide. It is **sleek and soft to the touch.** When the animal is dead, its skin is made into a useful kind of leather **for covering chairs** and **sofas,** for making **harness,** and for **stout, strong gloves.**

The skin is covered with thick, short **hair**; the hair grows **thicker as winter comes on,** and some of it falls off before the next summer. Why?

The horse's coat looks smooth and glossy; his master has him frequently washed, and scrubbed down with the **curry-comb.** He also keeps the **coat clipped short.**

Horses are not all the same **colour.** There are **white, black, bay, dun, grey,** and **dappled** horses.

The horse has a short, thick, pointed **tail,** which is entirely covered with long **stiff hairs** hanging down to the ground.

2. **Neck and head.**—The neck is long and arched, and from its upper edge hangs long, flowing hair, which we call a **mane.** A **tuft** of the mane hangs on the front of the head **between the ears.**

The head is **long** and **somewhat pointed** towards the **muzzle**; the **jaws** are especially long.

The **eyes** are large and so set in the face that the animal can see not only in front but on both sides of him.

The **ears** are short, erect, and pointed, and very **sharp of hearing.** He "pricks up" his ears at the least sound. He can erect each ear separately. A **bad-tempered** horse throws his **ears back.**

The **nostrils** are large, fleshy, and open. They have a very **keen sense of smell.**

The **lips** are thin and strong with a very delicate sense of touch. They help the horse to **crop** the short grass of the field.

3. **The teeth.**—*Show a picture of the skull of a horse and refer to lesson on "The Cow" and "The Sheep."*

Who can point out one important difference between the teeth of the horse and the cow? The **cow has a hard pad** instead of teeth in front of the upper jaw. The horse has **six sharp cutting teeth** in front of each jaw, but **no pad.**

The cow and the horse do not feed in the same way.

Picture them in the field, and lead the class to tell how the cow crops and swallows the grass—gathering up the tufts with her lips, pressing them with the lower front teeth against the pad, and then tearing them off by **jerking** *the head to the side.*

The horse actually bites or nibbles off each mouthful of grass with his two rows of **sharp, front cutting teeth.**

Which of the two animals would get its fill of grass first—the horse or the cow? The cow.

Why? Because the cow simply tears or bites off the grass and swallows it at once, without waiting to chew it. She chews her cud later on.

The horse does **not chew the cud.** He bites off and chews his food mouthful by mouthful.

But we have not done with the horse's teeth yet.

Show the picture again. Point out the rows of great **molars** *or* **grinding teeth,** *top and bottom, and make the children tell the purpose of such teeth.*

The food of the horse is **entirely vegetable,** consisting of hay, grass, corn, etc.

With such an arrangement of the teeth what can you tell me as to the movements of the jaw itself? It moves sideways as well as up and down.

Why? It is the sideway movement which causes the rough edges of the teeth to rub against each other and so grind the food, like corn is ground between the rough edges of the mill-stones of the mill.

Now look at the long **space** between the **front teeth** and the **grinders.** There are no teeth at all here. If we were to examine the mouth of any horse, we should find the same space—not because the teeth have fallen out, but because there never were any in that part of the jaw.

Show a horse's bit and tell its use. Tell that when the bit is put into the horse's mouth it fits into the space between the front teeth and the grinders.

If the teeth were placed all round the jaws as ours are, it would be impossible to put the bit into the horse's mouth—at least he would not be able to shut his mouth with the bit in it.

4. **The hoof.**—The foot is all one **solid piece,** it is really a **single toe.** This toe is enclosed in a **horny case** or **hoof,** like that of the cow, except that it is **not cloven.**

In its wild state the horse lives on the smooth grassy plains and its hoofs grow as quickly as they wear out.

Our domestic horse has to travel and draw loads over rough, stony roadways, and his hoofs would wear away quicker than they can grow. This is why we nail iron shoes to his hoofs. It is to preserve them.

The **farrier** can cut and trim the hoofs just as we cut and trim our nails without giving any pain, for they are made of the same kind of horny substance. It does not give the horse pain when the long iron nails are driven through the hoofs.

III. USES

Not only is the horse very useful to us while he is alive, but when dead every part of the animal is put to some use.

His **skin** is tanned to make **leather**; his **hair** is used for **stuffing cushions** for chairs, sofas, etc.; his **flesh** is used for **cat's meat**; his **fat** is used for making **soap**; the **hoofs** and **waste cuttings** from skin and bone are made into **glue**; and his **bones** are either made into **articles of daily use** or burnt to make **charcoal.**

Lesson XXVII

THE RABBIT

I. Introduction

Show a picture of some rabbits in their natural state.

Who knows these little animals? Where did you see one before?

You keep them, do you? But those you keep are tame rabbits and live in a **hutch.** These in the picture are not tame. They live quite wild in the fields and woods.

Boys and girls in the country often see rabbits running about. Now we are going to learn something about these little animals.

II. General Appearance

Show, if possible, a stuffed specimen, and lead the children step by step to notice the chief points in the animal.

1. **Size and covering.**—*Elicit from them that it is about the size of the cat, and like the cat it has a* **thick, soft, warm coat of fur.**

The pretty tame rabbits at home in the hutch may be of various **colours**—black, white, brown; but the wild rabbits are always **grey** or **brownish grey.**

2. **Ears.**—The ears are long and either stand upright or hang down. The rabbit can easily move its ears. At the least sound up they go.

3. **Eyes.**—*Show that the eyes are large and bright, and are placed at the sides of the face to enable the little creature to see all round it.*

4. **Mouth and teeth.**—*The peculiar form of the upper lip should next be shown, with its long* **cleft** *dividing it into two halves, both movable.*

The teeth are different from those of any animal we have yet examined.

The four front teeth, two in the upper and two in the lower jaw, are **long, broad, flat,** and **very sharp** at their **edges.**

They are in fact four sharp **chisels.** We often call them chisel-teeth.

Show a chisel. Illustrate its use. It cuts off pieces of the wood in slices.

The rabbit uses these four front teeth to **gnaw** or nibble its food.

We call the animal a **gnawing animal** because of this. It is to help the rabbit in its gnawing that the upper lip is split or cleft in two.

Point this out again, and let the children examine the teeth closely.

Call attention to the peculiar form of edge in the chisel.

After the carpenter has used his chisel for some time, what happens to it? It becomes **blunt** and will not cut.

Why is this? Because the steel wears away with the work.

Then if hard steel wears away, is it not strange that the rabbit's teeth do not wear away? Let me tell you how it is.

The **under part** of the teeth is made of much **softer substance** than the front or outer part. As therefore the teeth are used, the softer part wears away more quickly than the hard outer part and the edge is always kept sharp.

But the carpenter's chisel in time wears away, and he gets a new one. The rabbit never wants new teeth, because as fast as they are worn away they grow and are pushed up from the jaw, and so are always kept the same length.

But there are **other teeth** besides these chisel-teeth. In each **upper jaw** there are **six grinding teeth,** and on each side of the **lower jaw five.** These have sharp, rough, rasp-like crowns for the purpose of grinding the food, which the chisel-teeth have cut off in slices.

Lead the class to tell what must be the working of the lower *jaw in such an animal. There must be not only an up-and-down movement for the gnawing, but also a grinding movement similar to that in the cow and horse.*

5. **Whiskers.**—*Notice next the long hairs or bristles standing out on each side of the mouth.*

Do you know any other animal that has these hairs? What do we call them? **Whiskers** or **feelers.**

What is their use? They enable the animal to **feel its way** when it is too dark to see.

6. **Claws.**—The fore-legs are shorter than the hind ones. Rabbits run very quickly, but as they run, they seem to **bob and jump** about, because **their legs are not all the same length.**

Each foot has four toes, and the toes are armed with **thick, blunt claws.** The claws are for **scratching** in the earth. We shall in the next lesson see how the animal uses them.

Lesson XXVIII

THE RABBIT—*continued*

I. RECAPITULATORY

LEAD the class step by step to describe the general build of the animal as it was given in the last lesson. Be careful to show how the nature and habits of the creature are dependent on its structure.

Here we have a timid, frightened little animal with no means of defending itself against its numerous enemies. Nature gives it a pair of large wide open ears, and places the eyes at the sides of the face. The ears it can erect and turn in any direction, to catch the faintest sound; and the eyes can see readily on all sides. In this way it gets timely warning of all danger, and then is able to make use of its swiftness in running or rather leaping off. It was intended to live on roots and other vegetable food, and its chisel-teeth were provided for nibbling or cutting away its food in slips or slices, fit for the grinding teeth to chew.

Lead the children to describe the peculiar structure of these chisel-teeth—the reason why part of the tooth only wears away—the result of this wearing away—the manner in which the chisel is kept in working order.

Notice too the thick, warm, fur covering, just fitted for an animal meant to live in the open air. The colour of the little wild rabbit too is just the colour of the ploughed fields over which it loves to scamper.

The whiskers are for feeling its way in the dark, when the eyes are no longer of use.

The claws are made for scratching and digging in the earth.

We are now going to learn the special use of these.

II. RABBITS AT HOME

In all parts of the country rabbits live wild in the fields and woods. They are very **frightened, timid** creatures, and like to hide away out of sight in their home.

But their home; what is it? Rabbits make their homes underground. How do they do this? They use their **strong feet** and **stout, blunt claws** to **burrow** or dig holes in the ground.

They always choose a **sandy spot,** often on the sunny side of a hill, where it will be sure to be warm and dry, and here they set to work. They dig easily in the sandy soil with their feet, and make long winding passages or **burrows** under the ground.

They always **live together** in great numbers and make their burrows side by side. A great many burrows close together form a **warren.**

Lead children to see that in their burrows the little animals are safe from all their enemies, because the long winding holes are only just big enough for them; bigger animals, such as **foxes** *and other wild* **flesh-eaters,** *cannot make their way into them.*

Here at the end of these long passages the mother rabbit makes a nice, snug bed of **grass, hay,** or **straw,** and to make it still warmer and more cosy she covers this with **fur** from her own body. This is where the tiny rabbits are born and kept safe.

But how do they get on in tho **dark?** for it is dark in those underground passages. Their **feelers** serve them **instead of eyes,** so that they know were they are going.

Tell that they are rarely seen abroad during the day, certainly never far from their burrows, but after **dusk** *and in the early morning they love to scamper over the fields. The colour of their* **fur,** *which is* **very like the colour of the earth,** *serves to hide them from any of their* **prowling enemies,** *and their* **sharp ears and eyes** *tell them if any* **danger approaches.**

Picture them scampering off into the corn-fields and turnip-fields.

Why do they go there? To get food. They do much **damage** by gnawing the farmer's crops, and the farmer often takes his gun in the morning and evening and makes short work of the little prowlers.

III. Some of the Rabbit's Cousins

The animal most like the rabbit is the **hare.**

Tell the chief points of difference in **size, colour, mode of living,** *etc.*

Other gnawing animals are **rats, mice, dormice, squirrels.**

Lesson XXIX

THE MONKEY

I. Introduction

Call attention to the hand. Compare it with the foot. Show that in both there is the same general structure—five fingers of the one corresponding to the five toes of the other—the great toe *and thumb having similar positions—the foot with its thick solid instep and short toes—the hand with its long fingers—the* **purpose** *for which hand and foot are adapted; and so on.*

Pick up a stick or some other object and grasp it firmly in the hand.

Now, could I do this with my foot? No. Why not?

This will lead up to the difference in form and adaptability of thumb and great toe—that is, the essential difference between hands and feet.

Tell briefly of the **uses of the human hand**; *the strength of its powerful grasp, the delicacy of its touch, and so forth.*

II. FOUR-HANDED ANIMALS

Now look at this picture. Can you tell me what it is? It is the picture of a monkey.

Who has ever seen a live monkey?

Lead up to the fact that in our country monkeys are not found wild in the woods, as we find some of the animals, but that in some parts of the world monkeys are as **numerous** *as rabbits are here.*

Now have a good look at the picture and see what we can find out about this funny-looking animal.

Lead the children to tell of the **hairy body**, *the mischievous-looking* **face**, *with its small cunning* **eyes**, *the long* **arms** *reaching nearly down to the knee.*

Compare it with the human arms. There is no animal so much like man as the monkey. But let us see in what way the monkey differs from man.

We have two hands and two feet; we stand and walk on our feet. Now look at the monkey.

Are they feet? No, they look like hands. They are really hands.

The monkey has **four hands.**

We call it a four-handed animal.

Show the thumb, and make the class tell the great **use of a thumb.**

It is meant for **grasping** purposes. Monkeys with their four hands are meant to live in the trees. They use their hands to grasp the branches. They are extremely sharp and nimble at **climbing.** They spring from bough to bough and are perfectly at home.

But our monkey in the picture stands on the ground. Does he look at home there?

Point out his awkward, stooping attitude. Picture him walking along the floor.

Men and women, boys and girls walk with their heads erect. Look at him. He stoops down, and as he moves he steadies himself by resting his long arms on the floor.

The monkey is altogether out of place on the ground. His proper home is in the trees.

Monkeys are found in the dense woods and forests of the hottest countries of the world, where they live chiefly on fruits and nuts.

III. THREE CLASSES OF MONKEYS

1. The apes, which have no tails.
2. The baboons, which have very short ones.
3. The monkeys, which have long ones.

1. **The Apes.**—*Show a picture of the* **gorilla.**

This huge ape is from 6 to 7 feet in height, and has enormous strength. The **body** is covered with **hair of an iron-grey colour,** but the hair on the **head** is usually **reddish-brown.** The **palms** of the hands and **part of the face** are **bare,** and **jetty black.**

He is found in the dense forests of West Africa. He always **attacks** a man if he meets one. He works himself up into a **rage** by beating his breast with his huge hands, making it sound like a drum.

Tell of the **chimpanzee** *of West Africa and the* **orang-outang** *of the islands south of Asia.*

All three climb trees very readily. They make nests for themselves by twining the branches together. The

trees are their **home,** their **food-store,** their **look-out,** should any danger approach.

2. **The Baboons.**—These have very short tails. They are very fierce and strong.

Show a picture of one—the **mandrill,** *if possible.*

He is not only the largest and most ferocious of all, but has a peculiar face marked with bright colours—scarlet, dark purple, and light blue. He is as **tall as a man.**

3. **The Monkeys.**—These are much smaller than the apes and baboons and have long tails. They live in the forests of Asia and Africa and also in America.

The American monkeys are very different from those of Asia and Africa. The **thumb** is either very small indeed or altogether missing, but the **tail** is of great length, and the creatures use it as a sort of **fifth hand.**

They are most **expert climbers.** They live entirely in the trees, and pass from one to the other with the greatest ease.

Tell of the monkey-bridge—their mode of crossing a stream.

The monkeys of Asia and Africa form a great many distinct classes. They are **distinguished** by their **cheek pouches.**

Describe the loose, wrinkled, bag-like cheeks, and how these creatures make use of them for stowing away nuts and fruit as they gather them in the trees. Tell of the **monkeys of India.**

These monkeys live not only in the woods and forests, but infest the towns, living on the **house-tops** and plundering and robbing whatever they can lay their hands on.

The people of India never interfere with them, no matter what mischief they do. Indeed it would be death to the man who killed one of these monkeys.

They build splendid temples for them, and even hospitals to nurse them if they are sick.

Lesson XXX

THE MOLE

I. Life and Habits

Show a picture of the mole. Tell that this is a little animal about the **size** *of a* **small rat.**

Moles live in most parts of the country. Yet they are very seldom seen alive.

Explain that the mole **lives underground.** *Rabbits live underground too, but they are often seen frisking about in the fields.*

Why do we so frequently see rabbits? They come out of their burrows morning and evening to feed.

What is their food? Where do they find it?

In this way lead the children to see that the rabbit burrows in the earth to make itself a snug, safe home, where it can live and rear its young. It must come to the surface to feed, and it loves its scamper over the fields.

Now tell that the mole chooses an **underground home,** *not simply because it is safe, snug, and cosy, but because the* **food** *on which it lives is* **underground** *too.*

He is born underground; he lives, eats, drinks, works, and in all probability dies there.

What sort of food do you think he can find underground?

Excite the curiosity of the children, and then tell them that—

He is a fierce, hungry little creature, and would not be satisfied with such food as the rabbit eats. He catches other little animals and eats them.

What sort of animals can he find in the earth?

What have you often found when digging in the garden?

Tell of worms and grubs that live underground. These are the natural food of the mole, and it is because he lives on such food that he makes his **home in the earth.**

Tell of the **mole-hills** *which are often seen in the fields.*

Perhaps you will say, "What a dark, cold, dirty, cheerless life his must be." Let us see.

II. How fitted to live Underground

Show the picture again, and call attention to the **structure** *of the animal, point by point.*

1. **Shape of body.**—He has a short, thick, rounded **body** with a strong, **pointed snout,** and the four legs are very short.

Which could you force into the soil best, a round, pointed stick or a blunt, square one? The pointed one.

The shape of the mole's body, therefore, is just fitted for **tunnelling** in the earth, and the short legs are not in the way as he moves.

2. **His fore-paws.**—*Call attention to the broad, flat, shovel-like paws, with their long, strong claws.*

They are splendid digging tools.

Notice too that they are **turned outwards,** *so that they can throw back the soil as they dig.*

3. **His fur.**—*Show the skin of a mole.*

He is really a handsome little animal, with his black, glossy, fur coat, as smooth and even as velvet.

What a beautiful coat for the damp, dirty soil!

Do you think he has much trouble to keep it clean? No, he has not, for it never gets dirty. Whenever the mole comes up from his tunnel, his coat is always sure to be clean, smooth, and glossy. Let us see why this is?

We should get dirty enough if we had to crawl through the earth.

The short hairs of the fur grow **perpendicularly** up from the skin, instead of lying flat, as the fur of most animals does.

Show a piece of some fur.

Point out that the little hairs are coarse near the roots and finer at the ends.

Tell that in the mole it is just the opposite. The hairs are **fine at the root** *and* **coarse at the ends.**

Rub the cat's fur the wrong way *and it ruffles up. But it does not matter which way the mole's fur is rubbed.*

It bends easily either way, and not only never ruffles but will not allow any of the soil to stick to it. It all shakes off as he moves to and fro in his underground work. The mole, although he lives in such a home, is never dirty.

Notice how **thick and close** *the* **fur** *is. It makes a snug, cosy coat to keep him warm as he lies in the cold, damp earth.*

4. **His eyes.**—He lives in the dark earth, where not a ray of sunlight ever penetrates. Hence he has little use for eyes. Then, too, what would happen while he bored his way in the earth with snout and paws if his eyes were like those of other animals?

Little particles of earth would get into them, and cause him **pain and injury.**

Tell that the mole's **eyes** *are very* **deeply set,** *and completely hidden in the thick fur.*

People used to think that the mole had no eyes, because they could never see them.

The **mole's eyes** are like **two little black beads,** and may be easily seen by dipping the little animal in water.

5. **Sense of smell and hearing.**—In the utter darkness underground the mole's eyes are all but useless to him.

Lead the children to see that he must have some means of finding his way as he prowls about in search of his prey.

Tell that his **sense of smell** *is very keen and his* **hearing very sharp.** *These guide him in place of eyes.*

A strange thing about him, however, is that there are **no outer ears to be seen** like those of other animals.

Tell why.

Explain how easily sound travels through the earth. Tell that it is easy to hear the rumbling of the wheels of a cart at a great distance by putting the ear to the ground.

The noise made by little animals forcing their way through the earth is quickly conveyed to the mole, and away he hurries after them.

Picture a worm in the ground. How rapidly it draws itself back on the approach of danger. The mole must be very rapid to catch his prey.

6. **His teeth.**—The mole's teeth are long, sharp, and pointed—made specially for seizing and tearing flesh, not for chewing. He is a greedy, ravenous, little animal, and cannot go long without food.

He catches and kills **frogs, field-mice,** and **snakes,** as well as **earth-worms** and **grubs.**

The moment he has killed his victim, he tears open its belly, thrusts his snout into it, and begins his meal by gorging himself with its blood.

The farmer often lays traps to destroy the poor moles, but although they do some damage to the crops by their tunnelling, they certainly do a great deal of good, by devouring grubs and beetles which would otherwise kill the growing plants. After all, he is one of the farmer's friends.

OBJECTS AND OTHER ILLUSTRATIONS REQUIRED

STANDARD I

Lesson I

A jug, basin, saucer, tumbler, bottle, square tin box; some water, sawdust, quicksilver, oil, vinegar; a brush.

Lesson II

A basin, tumbler, iron spoon, spirit-lamp, large pill-box; some pieces of stone, wood, iron, and wax.

Lesson III

Pieces of flint, iron, wood, feathers, cork, chalk, lead, steel, glass; some cotton-wool; some small sponges; a potato, turnip, apple; a knife; a hammer.

Lesson IV

A basin, saucer, large sponge; some water, bread, pumice-stone, wood, coke, charcoal; ball of lead; chalk; loaf-sugar; a pair of scales.

Lesson V

Specimens of clay, dry and moist; a knife; a hammer; some water, wool, sponges.

Lesson VI

A basin; some soft clay, red ballast, water; pieces of brick and flower-pot; a few specimens of earthenware goods.

Lesson VII

Some putty, soft and hard.

Lesson VIII

Some putty, chalk, whiting, linseed-oil; a basin of water.

Lesson IX

A basin of hot water; specimens of gutta percha; pieces of rusty iron; picture of the gutta-percha tree.

Lesson X

A tumbler; some common salt, wax, sugar, soda, lime, alum, water; an iron spoon; a spirit-lamp; a plate; pieces of flint, glass, wood, chalk, and iron.

Lesson XI

A tin dish and tripod; a spirit-lamp; some rock-salt, common table-salt, water, and sugar.

LESSON XII

Some sugar (coarse moist, and loaf); a fresh cabbage-stump; some woollen or flannel bags; picture of the sugar-cane.

LESSON XIII

The spirit-lamp, tongs, and tin saucers; pieces of calico, cotton-wool, cloth, silk, wool, muslin, linen, paper, thin leather, whalebone, coal, coke, stone, clay, chalk; some splinters of wood; some feathers, hay, straw, paraffin, and benzoline.

LESSON XIV

The spirit-lamp; a hammer; tongs; pieces of charcoal, peat, common coal, clay, rock-salt, chalk, stone, slate; a carrot; a potato.

LESSON XV

Specimens of fossil coal, or a picture; pieces of cannel anthracite and common house-coal; a clay tobacco-pipe with a long stem; some soft clay; some powdered coal.

LESSON XVI

Remove the lid from a starch or baking-powder box; replace it with a glass front; fill in with several layers of earth, clay, stone, sand, gravel, coal, etc., of various colours and varying thicknesses, placing the coal layer on clay, and nearly at the bottom. Make, if possible, a shaft running through the layers to the coal-seam. A cardboard house or two on the surface and a little paint would add to the effect.

LESSON XVII

Picture showing miners at work; a soda-water bottle filled with coal-gas and air; the spirit-lamp.

LESSON XVIII

Picture or sketch of the Davy lamp; some wire gauze; a contrivance for illustrating the ventilation of the mine, as shown in the figure below.

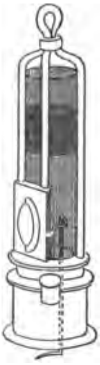

FIG. 1.

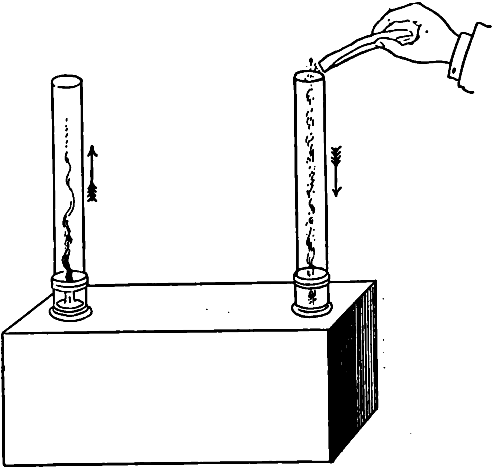

FIG. 2.

LESSON XIX

A thin stick of wood; pieces of lead, leather, wool, hair, india-rubber, flannel, woollen cloth; a silk handkerchief; a watch-spring; a large sponge; a bottle and cork; a strip of whalebone; some copper and iron wire.

LESSON XX

Pieces of india-rubber, leather, vulcanized rubber, elastic cloth; a spirit-lamp; test-tubes; cold and warm water; turpentine; naphtha; india-rubber ball and tubing; and india-rubber solution.

LESSON XXI

Picture of a cat; sketch on black-board of the cat's head to show specially the **eyes** and the **whiskers.** The teacher should first show the pupil of the eye as a long narrow slit, and afterwards widen it into a circle to mark the change that takes place as night comes on.

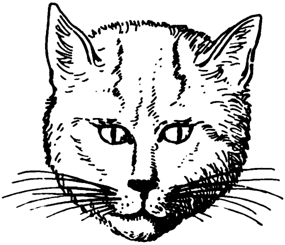

FIG. 3.

Sketches of the cat's paw; one to show the pads, the other the outstretched claws;

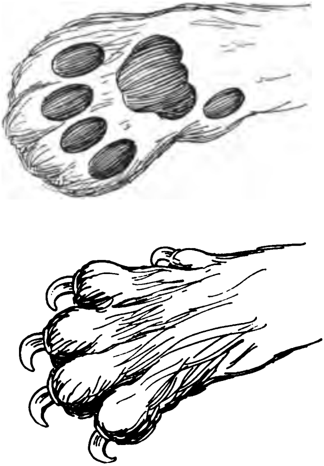

FIG. 4.

sketch of cat's head; mouth open showing the teeth.

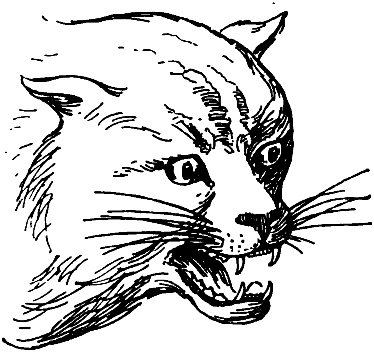

Fig. 5.

Lesson XXII

Pictures of the tiger, lion, leopard, and any others of the cat family.

Lesson XXIII

Picture of a dog.

Lesson XXIV

Pictures of a wolf and a fox, a greyhound, St. Bernard, bulldog, sheep-dog.

LESSON XXV

Picture of a sheep; black-board sketch of a sheep's skull, to show the teeth.

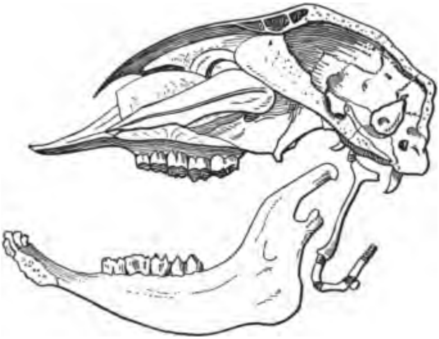

FIG. 6.

LESSON XXVI

Picture of a pig; specimens of bristles and pig-skin leather.

LESSON XXVII

A hammer; a stone; a growing plant in a flower-pot; another plant in actual flower; some scarlet-bean seeds.

LESSON XXVIII

Some oats, barley, or wheat growing in a pot; one or two simple annuals; a carrot, turnip, and parsnip; a tumbler of water.

LESSON XXIX

A scarlet-runner, a sweet-pea, and (if possible) a strawberry plant growing in flower-pots; pictures of any twining plants; piece of vine stem; a root of garden mint; a picture of a growing potato-plant.

Lesson XXX

A large onion; a lily and a hyacinth bulb; piece of oak stem; piece of thick cane; a small willow branch.

Lesson XXXI

Leaves of lime, cucumber, vine, mallow, cabbage, lettuce, geranium, flag, and grasses.

Lesson XXXII

Leaves of apple, pear, plum, cherry, oak, vine, rhubarb, vegetable-marrow, scarlet-bean, clover, strawberry, rose, horse-chestnut, Virginia creeper, ivy, holly, laurel, or as many of them as can be got.

Lesson XXXIII

Specimens of some simple flowers; a lily.

STANDARD II

Lesson I

A tumbler; some water; a piece of cane; a glass rod; some turpentine, flannel, blotting-paper; a paraffin lamp, a candle, and some pieces of wick.

Lesson II

Some specimens of sponges; picture of the sponge-diver.

Lesson III

A common coffee-strainer; some flannel bags, blotting-paper, chalk; a tumbler of water; a large flower-pot; sponge; charcoal; fine sand; some flour.

Lesson IV

Some hot and cold water, salt, chalk, starch, lime, blotting-paper, loaf-sugar; two or three tumblers and spoons; glass tube; nitrate of silver and ammonia solution.

Lesson V

Some soda crystals and a strong solution of soda; camphor (solid and in solution), naphtha-solution of india-rubber; a bottle of oil; basin of water; a tumbler; some soft soap.

Lesson VI

A gum-bottle and brush; some paste; a postage-stamp; stick of sealing-wax; glue and glue-pot; plaster of Paris.

LESSON VII

An iron spoon; common glass flask; glass tubing; the Bunsen burner; some wax, wood, coke, brick, slate, stone, loaf-sugar, roll-sulphur, lead.

LESSON VIII

Specimens of all the common metals; some bright steel article; a rusty knife; a hammer; wash-leather; sheet-iron; gold and silver leaf; copper and tin foils; specimens of wire.

LESSON IX

Some iron-ore, sulphur; an iron spoon; spirit-lamp or Bunsen burner; a few steel articles; picture of a blast-furnace; black-board sketch of puddling-furnace, showing how the flames play on the pigs of iron although the fuel does not touch them.

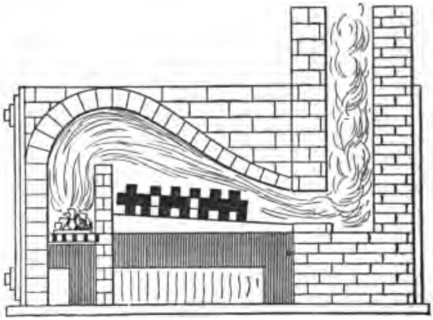

FIG. 1.—SECTION OF PUDDLING-FURNACE.

LESSON X

A few articles made of cast-iron; thin bar of lead; some wax; an iron spoon, spirit-lamp, and a pill-box.

LESSON XI

A few articles made of wrought-iron ; a small iron bar ; a hammer, poker ; some iron wire of various thicknesses ; some soft clay ; sheet-iron ; a "tin" saucepan.

LESSON XII

One or two polished steel articles ; some steel pen-nibs ; a tobacco-pipe ; a basin of cold water ; a watch-spring and a lock spring ; a chisel, knife, or razor.

LESSON XIII

One or two polished copper articles ; a thin sheet of copper ; copper-foil ; copper wire ; a brass object of some sort ; a bell ; copper ore.

LESSON XIV

Some lead, iron, and copper articles ; sheet-lead ; lead-foil ; lead piping ; a hammer ; pewter spoon ; solder ; soldering-iron ; spirits of salt for soldering ; bullets ; shot ; lead-ore.

LESSON XV

Specimen of polished tin ; iron, copper, and lead ; tin-foil ; iron spoon ; some "tin" ware article ; tin-ore.

LESSON XVI

Specimen of polished zinc ; copper, tin, iron ; sheet-zinc ; a piece of rusty iron ; galvanised iron pail ; perforated zinc ; garden wire ; zinc-ore.

LESSON XVII

A bright silver article; specimen of polished tin; silver-leaf; silver wire; silver coin tarnished with sulphur.

LESSON XVIII

Some gold-leaf, gold wire, gold lace; a gilt-edged book.

LESSON XIX

Some common starch, water, wheaten flour; a tumbler, basin, and spoon; kettle of boiling water; a piece of muslin; some prepared wheaten starch; some maize; a potato; a rasp.

LESSON XX

Drawing of the starch grains magnified; specimens of sago, arrowroot, and tapioca.

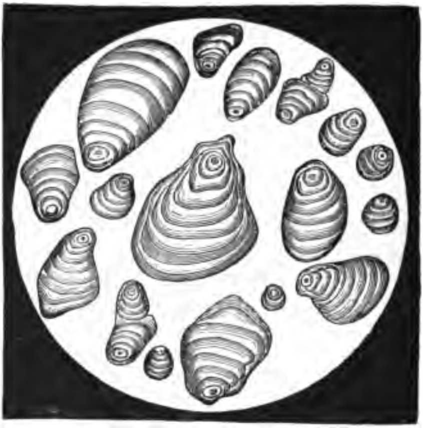

FIG. 2.—STARCH GRANULES FROM THE POTATO. (Multiplied 300 diameters.)

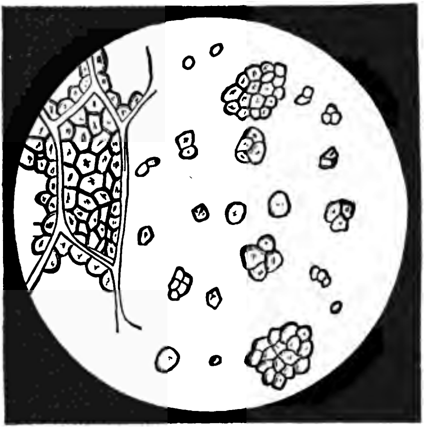

FIG. 3.—STARCH GRANULES FROM RICE. (Multiplied 300 diameters.)

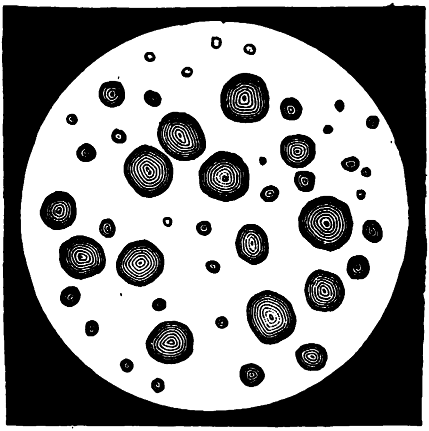

FIG. 4.—STARCH GRANULES FROM WHEAT. (Multiplied 300 diameters.)

N.B.—It would be well for the teacher to reproduce these on a sheet of paper, rather than on the black-board, for inspection by the class. The grains are in each case magnified about 300 diameters.

The fact should be impressed upon the class that, large as the grains of potato-starch appear in this drawing, they are in reality so minute that it would take 400 to 500 of them to measure an inch; and they are more than ten times as large as the rice grains, for it would take 5000 of these to measure an inch across.

LESSON XXI

Some flour ; some grains of wheat ; a bunch of tall grass ; picture of the corn plant ; some ears of wheat, barley, oats ; some oatmeal ; some malt ; a basin of water ; a muslin bag.

LESSON XXII

Some grains of rice ; a hammer ; some rice-flour, wheat-flour, barley-meal, oatmeal, bran, whole flour, and pure whites ; picture of the rice plant ; specimen of paddy.

LESSON XXIII

Some grains of maize and the other cereals ; a cobb of maize ; picture of the growing plant ; some corn-flour.

LESSON XXIV

Picture of a cow ; black-board sketch or drawing on paper of the skull, showing the arrangement of the teeth ;

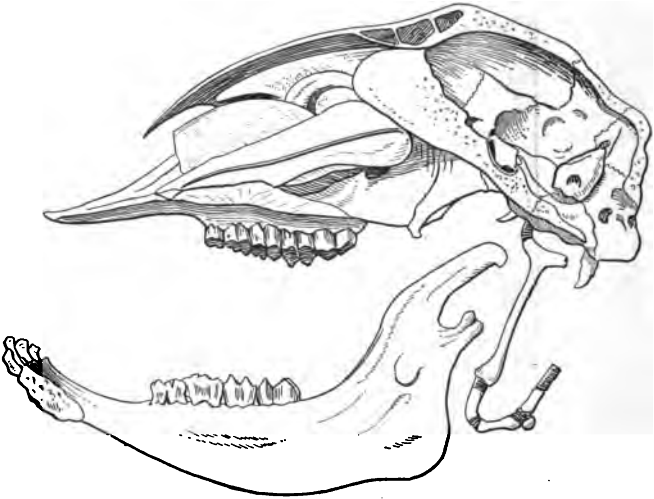

FIG. 5.—SKULL OF THE OX.

black-board sketch of the four stomachs;

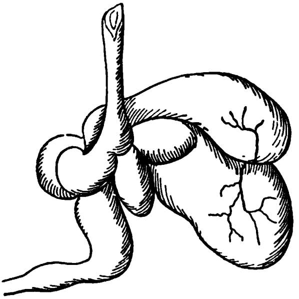

FIG. 6. External view of the four pouches, with the gullet attached.

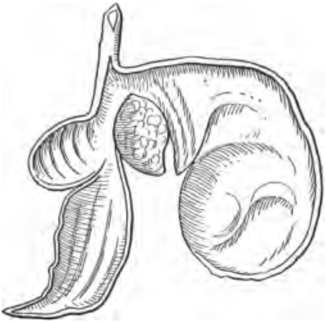

FIG. 7. The same cut through to show the internal arrangement.

some specimens of leather.

LESSON XXV

A glass of fresh milk; some milk that has been left to stand in a shallow dish; a soda-water bottle; picture of a dairy; some vinegar or rennet.

LESSON XXVI

Picture of a horse; black-board sketch or drawing of the skull, to show the arrangement of the teeth; a horse's bit; some glue and horse-hair and a piece of sole leather.

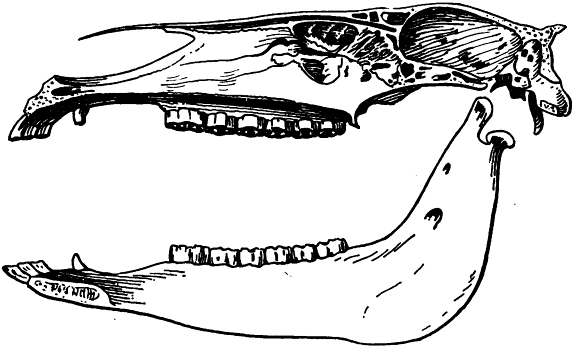

FIG. 8.—SKETCH OF HORSE'S SKULL.

LESSON XXVII

Picture of rabbits; a small live rabbit or a stuffed specimen; a carpenter's chisel.

LESSON XXVIII

Picture of wild rabbits; and any of the rodent family.

LESSON XXIX

Picture of monkeys; the gorilla; the mandrill.

LESSON XXX

Picture of the mole; a dried stuffed specimen; some cat's or rabbit's fur.

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